UNIVERSITÀ DI PAVIA
Department of Economics and Management

DEM Working Paper Series

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 # 221 (07-24)

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Abstract

Initial Coin Offerings (ICOs) have emerged as a novel way of start-up funding based on blockchain technology and this paper aims to explain the nexus between ICOs business purposes and underpricing, i.e. when the price of the offered token is lower than the one traded on the market. In particular, we focus on the impact of the Environmental, Social and Governance (ESG) pillars on the ICOs' underpricing. Therefore, we built up a wide and comprehensive dataset comprising ~ 8000 ICOs spanning from 2015 through 2023, containing both technical and financial information. Moreover, we assessed an ESG score using AI-based textual analysis performed over the whitepapers. The main results show that a higher ESG orientation leads to less underpricing, especially in the early trading days. Our findings may represent a useful support to an enhanced and reliable decision-making process.

Keywords: Initial coin offering (ICO), ESG, Text analysis, Underpricing

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1. Introduction

In recent years digital technology has progressed substantially. Besides artificial intelligence, blockchain technology can be identified as one of the pillars of these advancements. In particular, Initial Coin Offerings (ICOs) are a novel way of gathering capital, especially used by young firms and start-ups, that utilise so-called "Tokens", which are a kind of crypto-asset that is sold to investors. Afterwards, the former can either trade them on exchanges or use them for buying products and services developed by the firm conducting the ICOs (Benedetti and Kostovetsky, 2021). The history of Initial Coin Offerings begins in 2013 when the first ICO was launched and since then, there has been an increase in both the funding amount and the number of ICOs conducted (Bellavitis et al., 2021). The focus of this paper deals with the well-known phenomenon of underpricing, i.e. when "the price jumps substantially on the first day of trading" (Ljungqvist, 2007) compared to the price at which it was sold during the offering. So, if a token's price during an ICO is lower than the one on the first day it is traded, it can be considered underpriced. This issue per se is well studied in the literature, as it typically occurs in a similar context represented by Initial Public Offerings (IPOs) (Allen and Faulhaber, 1989, Loughran and Ritter, 2004, Ljungqvist, 2007). Authors have found that firms conducting an IPO can be underpriced for various reasons, e.g., country-specific regulations (Supriya Katti, 2016). The question of whether those factors also influence ICO underpricing has been studied in recent years by several authors, together with the question of whether a reduction of information asymmetry reduces ICO underpricing as it does with IPO underpricing (Benedetti and Kostovetsky, 2021, Florysiak and Schandlbauer, 2022). This is important for both investors and entrepreneurs, as there might be specific characteristics at the different levels (e.g., firm, country, timing), that might influence the severity and occurrence of underpricing. This paper examines, in particular, the influence of a firm's ESG orientation on underpricing, captured in the form of a score.

As the literature on the influence of ESG characteristics on ICOs is scarce and at the time of writing, no papers have been published yet that deal with the relationship between ICO underpricing and Environmental, Social, and Governance (ESG) topics, this paper aims at investigating such

hypothesis and at shedding light on the influence of other factors. This includes the length of the firm description issued before the ICO, the so-called "whitepaper", and also other factors, i.e., the firm's geographic location, the year in which the ICO occurred and the industrial category in which it is active. Our ultimate goal is to provide decision-makers and investors with a comprehensive, reliable and data-driven set of information to evaluate the consistency and the solidity of ICOs, leveraging on the power of state-of-the-art Artificial Intelligence techniques.

The rest of the paper is structured as follows: Section 2 explores the literature on ICO underpricing and related issues, also examining what is known about the connection between IPO underpricing and ESG in the process. Section 3 formulates our research hypotheses and explains the rationale behind them and Section 4 describes the data collection process and descriptive analysis of the variables. Section 5 introduces the methodology and reports the results. Finally, Section 6 concludes and explains limitations and future research.

2. Literature Review

2.1. Initial Coin Offerings

Initial Coin Offerings represent a relatively novel way for start-ups to raise money from investors using blockchain technology (Peter Roosenboom and de Jong, 2020). The European Securities and Markets Authority defines ICOs in the following way: "An ICO is an innovative way of raising money from the public, using so-called coins or tokens, and can also be called an initial token offering or token sale. In an ICO, a business or individual issues coins or tokens and puts them for sale in exchange for fiat currencies, such as the Euro, or more often virtual currencies, e.g., Bitcoin or Ether "(ESMA 11/2017[1] as cited in Filippo (2020)). The coins or tokens the ESMA is mentioning in its definition, are what defines an Initial Coin Offering at its core. Investors can buy those tokens during the ICO (Peter Roosenboom and de Jong, 2020), using either fiat money or other cryptocurrencies, such as Bitcoin or Ether. These tokens are digital assets made available

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[1] https://www.esma.europa.eu/sites/default/files/library/esma71-99-649_press_release_ico_statements.pdf

by the firm that is holding the ICO event by using distributed ledger or blockchain technology (Filippo, 2020). The key difference between ICOs and another quite recent form of funding, so-called crowdfunding, is the token. During ICOs, investors get a financial stake in the company in the form of a token - a mechanism that is absent during crowdfunding events (Kaal and Dell'Erba, 2017). The tokens are not merely regular cryptocurrencies used for storing and exchanging monetary value, like Bitcoin or Ether, but come with varying features.

There are common types of tokens that can be characterized by the purpose they serve. For example, there are the so-called "utility tokens" - which are the most common type of token issued in ICOs. These are used for accessing the services and ecosystem or acquiring the goods of the enterprise that issued and sold them to investors during the ICO.

Often, they are the only way of accessing a firm's future goods and services. Those utility tokens do not carry any ownership rights with them, in short, they are a very unregulated hybridisation of an investment and a payment instrument (Momtaz, 2020). However, at the time the tokens are sold during the ICO, no reasonable firm can already set the number of tokens that have to be spent by an investor to acquire its future product or service. Setting the wrong price would result in the firm not being able to operate under profitable conditions (Catalini and Gans, 2018).

The second type of tokens is "equity tokens" (Gan et al., 2021), also called "security tokens" (Momtaz, 2020), which, rather than providing access to the firm's goods, ecosystems and services, guarantee access to potential future profits of the issuing firm. The third form of tokens is "currency tokens", which, similarly to normal cryptocurrency, are a novel way to store and trade money (Howell et al. (2020) as cited in Campino et al. (2022)). Due to the ambivalent nature of those tokens, their legal classification and treatment is a grey zone (Filippo, 2020). Especially, the similarity of some kinds of tokens to regular shares issued during Initial Public Offerings (IPOs) represents a reason for such uncertainty.

Furthermore, tokens and coins sold during ICOs differ from other forms of cryptocurrency because, for example, Bitcoins are mined and validated in a decentralized way. Anyone with enough computing power can essentially create them through this mining process, while the tokens

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used in ICOs are created centrally by the firm itself (Filippo, 2020). In this regard, they are again quite similar to shares on the regular stock market, as the firm issuing them has a monopoly on token creation, with the ability to regulate how many of them it wants to put in circulation.

The first ICO took place in July 2013 (Bellavitis et al., 2021) and it was called the Master Coin Project (Campino et al., 2022). The Master Coin was successfully sold in exchange for Bitcoin, raising approximately $680000 during the ICO (Amsden and Schweizer, 2018). In 2015 firms conducted a total of 14 ICOs that raised $33 million, in 2016 112 ICOs raised almost $300 million (Boreiko and Sahdev, 2018). However, the market started gathering pace in 2017: in the fourth quarter alone almost $2.5 billion was raised by 169 ICOs (Boreiko and Sahdev, 2018). Benedetti and Kostovetsky (2021) report that since January 2017 over 1000 start-ups managed to raise approximately $12 billion. Furthermore, Bellavitis et al. (2021) state that for the time being the market for ICOs reached its peak in the first quarter of 2018 and a decline set in afterwards. Howell et al. (2020) (as cited in Campino et al. (2022)) even speak of a collapse of the market occurring in the third quarter of 2018.

Although there are no strict procedural regulations a firm has to follow when conducting an Initial Coin Offering (Boreiko and Sahdev, 2018), some typical features can still be outlined. Gan et al. (2021) identify the publication of a whitepaper as a first step. A whitepaper is a document which has no default content. It usually contains information about the nature of the venture, the regulatory and technical framework the firm operates in, the people involved in the team of the firm and the problem the enterprise seeks to address with its business proposal. The whitepaper's issuance became the norm in mid-2017. It can represent a concise piece of information handed out to potential investors who want to inform themselves about the venture. It thus serves a similar purpose as the prospectus issued for an Initial Public Offering (IPO). It is lacking its regulatory framework, thus relying more on common practices (Filippo, 2020). Kaal and Dell'Erba (2017) state that it is common for firms seeking to raise capital through an ICO to publish an announcement of their willingness together with an executive summary of their idea in relevant forums, such as Reddit or Telegram. On such social media platforms, a discussion with interested potential

investors then takes place. The results of such discussions can be analysed by the firm's team and integrated into the whitepaper afterwards. Furthermore, the aforementioned authors identify the so-called "pre-ICO". It is a sale of the token to a selected group of investors before the actual offering, an event that a part of the firms integrates into the sequence of events they go through on their way to raising capital. After this, the actual Initial Coin Offering takes place, where tokens are sold at a predefined price to everyone willing to buy them. Benedetti and Kostovetsky (2021) state, that to abide by money laundering - and "know your customer" (KYC) regulations, many ICOs require that investors register themselves to be able to partake in the token sale. Moreover, they point out that many firms predefine a maximum amount of money that they want to raise during the financing event, the so-called "hard cap". After reaching such a number, the ICO ends. At the same time, a "soft cap" is defined as the minimum amount of money that needs to be raised during the funding, to ensure the proper development of the project.

In comparison to more established ways of raising money, such as IPOs, Initial Coin offerings usually enable much cheaper fundraising, due to the absence of strict regulations and intermediaries. Furthermore, they are more inclusive than classic venture capital funding, which often does not allow small investors to participate in all of its activities (Kaal and Dell'Erba, 2017).

Gan et al. (2021) state that the potential for financial gains is high for entrepreneurs and investors. Also, they argue that the investor base is potentially much larger compared to other forms of fundraising, due to the aforementioned absence of bureaucracy. However, the ICOs market is still very risky, especially when no minimal viable product is presented and the lack of information is evident (Kaal and Dell'Erba, 2017). The lack of regulation on the market, enabling cheap financing with high liquidity without the need for intermediaries or underwriters in the first place, only increases the risk for small investors (Benedetti and Kostovetsky, 2021).

2.2. Drivers of ICO success

Many papers in the emerging field of ICOs literature have focused on the drivers of Initial Coin Offering success (Amsden and Schweizer, 2018, Belitski and Boreiko, 2022, Campino et al., 2022, Lyandres et al., 2022, Muhammad Farooq Ahmad and Pisany, 2023, Bitetto and Cerchiello,

2023, Peter Roosenboom and de Jong, 2020, Domingo et al., 2020). They are examining which variables, such as characteristics of firms, the time in which the ICO happened or the environments a firm operates in, influence a predefined measure of ICO success. Those measures of success can be defined in various ways, such as funds raised, coin tradability and reaching of the hard and soft cap. Amsden and Schweizer (2018) analysed potential influence factors on the total amount of funds raised, by using ordinary least squares regression. Also, they assessed the coin tradability, meaning the listing and post-ICO liquidity of tokens using logistic regression. Cerchiello et al. (2019) identified the existence of a whitepaper, the size of the company's team, the number of advisors, and the existence of a Telegram chat, to be drivers of Initial Coin Offering success. Furthermore, with their sample of 120 ICOs conducted in 2017 and 2018, they assessed that the absence of Twitter activity and the unavailability of a company website are signals of possible fraud. Special emphasis on the effect of governance signalling on ICO success and future listing was put by Giudici and Adhami (2019). They analyse 935 ICOs between 2014 and the end of 2017 and find that some of the governance signals they defined, positively influence the success of funding. They argue that a higher percentage of tokens retained by company insiders is one of those signals that lead to a higher success rate, as it increases the stake the people involved in the project have in its well-being.

Peter Roosenboom and de Jong (2020) examined 630 ICOs that took place from August 2015 to December 2017. They differentiate between funding success and ex-post success. Their measurements of funding success are the reaching of the soft cap, the total amount of funds raised and the tradability of the token. Ex-post success as defined by them means having a website that is online and working, the number of tweets per week and the activity of the venture on GitHub. The paper manages to identify several factors positively influencing these measurements of success, namely having a GitHub depository available before the ICO is conducted, holding a pre-ICO, not engaging in bonus schemes during the funding period, planning with a short duration of the ICO, having a large team working on the project and getting and disclosing crypto-expert ratings. Generally speaking, they find that disclosing more meaningful information to potential investors

increases the probability of success.

Also, Campino et al. (2022) point out the benefits of having a "well-structured and informative" whitepaper and analysing a sample of 428 ICOs in the banking and finance sector they found that the length of the whitepaper in general and disclosing technical information in it positively influence ICOs success. Analysing 503 ICOs from 60 countries conducted in the time between 2015 and 2018, Muhammad Farooq Ahmad and Pisany (2023) conducted a joint analysis of both country-level and individual-level characteristics of firms that may influence funding success. They confirm that the number of members in the venture team positively influences the outcome of the funding and find that the same is true for the number of advisors a start-up discloses before the ICO. In contrast to other authors (Peter Roosenboom and de Jong, 2020) they find that holding a pre-ICO where only selected investors can participate, negatively influences the success of the following offering. They report a negative influence of bonus schemes and in contrast to Amsden and Schweizer (2018), a positive influence of the Ethers development on ICO success.

Few papers have dealt with the influence of the ESG orientation of firms on the success of ICOs, the partial dimension of governance was explored by Giudici and Adhami (2019). Another noteworthy publication to that extent is Guzmán et al. (2020), where the authors analysed 324 Initial Coin Offerings between 2017 and 2019 of firms with an environmentally oriented business model. They found that the higher the attention is for global warming, the more funding is raised for such ICOs. Furthermore, they find that ICOs that occurred during a time of high awareness of the global warming problem complex, have a lower long-term likelihood of failure. Other papers follow a different approach, by aggregating information about the issue in a single score capturing information extracted from text sources, i.e., the whitepaper. For example, Mansouri and Momtaz (2022) create an ESG score by analysing the whitepapers of 1043 token offerings in a period of four years (2016 to 2020) with a machine learning model. This model uses an ESG dictionary of words manually created for that purpose. The authors show that the score they calculate is comparable to scores used by professional rating companies such as Refinitiv. They thus advocate for future authors who want to explore the ESG theme in the domain of start-up funding to use

this model and make it publicly available for this purpose. Their key result is that a "one standard deviation increase in the ESG-metric is associated with a 28% increase in the funding amount". This means that start-ups with a higher ESG score can raise higher funds during the ICO compared to non or low-ESG start-ups ceteris paribus. This is what the authors call the "Valuation Premium Hypothesis": ESG-related start-ups with the same business case as conventional ones should be valued higher due to the ESG-premium, a delegation of investors owns ESG goals onto the start-up is taking place, leading to a higher willingness to pay during the funding phase. Similarly, Bongini et al. (2022) analyse the whitepaper of 188 Security token offerings from 2017 to 2021 and through Topic Analysis they discover that among all projects, energy and environmental issues rank among the most popular, and that the likelihood of a campaign's success and the quantity of money it raises are strongly correlated with the disclosure of these issues. The other key hypothesis Mansouri and Momtaz (2022) develop is what they call the "Post-Funding Underperformance Hypothesis". They argue that financial equilibrium theory points out that investors' greater willingness to pay during the ICO phase must be followed by lower expected financial returns afterwards. Leading to an underperforming of ESG-related start-ups once the funding phase is completed, compared with conventional, non-ESG start-ups. Their results also support this hypothesis. The other relevant publication is Bitetto and Cerchiello (2023), which examines the ICO success in relation to the firms' ESG orientation. They use a binary variable, that flags start-ups as ESG-related above a certain threshold. The authors used a neural network model that does not rely on the compilation of a dictionary, further limiting the influence of researcher subjectivity on the classification of firms as ESG or non-ESG. As Mansouri and Momtaz (2022), Bitetto and Cerchiello (2023) analyse the whitepapers issued by firms planning to conduct ICOs to gather the textual information that they need to construct the ESG variable. In total, they analyse 871 ICOs and measure ICO success through a binary variable that is based on the ratio of the raised funds over the hard cap. By using models based on logistic regression, they discover that ICOs that are flagged as ESG-related are more likely to be successful. In addition, they confirm that the size of the venture team and the number of their advisors positively influence the success of an ICO. To conclude the analysis of

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literature regarding the success of Initial Coin Offerings, it becomes apparent that the unifying feature of all the publications presented here is the importance of the whitepaper as a valuable medium of information that is presented to the base of potential investors. The authors argue that it can provide information that is crucial to investors in an unregulated market as is the ICO one, such as the number of team members in a firm, the number of advisors and valuable technical details (Campino et al., 2022). Furthermore, informing investors on other channels, such as Telegram, Twitter, GitHub, and a dedicated company website increases the chance of successful funding (Amsden and Schweizer, 2018, Cerchiello et al., 2019). The presence of big investors such as venture capital firms or business angels before the start of the ICO also acts positively on success (Belitski and Boreiko, 2022). Disclosing information related to the ESG orientation of the firm seeking to raise funds through an ICO also increases the probability of success, if the firm is ESG-related (Mansouri and Momtaz, 2022, Bitetto and Cerchiello, 2023). The disclosure of this information acts as a signal that can build trust in investors, increasing the chances of success that ICOs have (Muhammad Farooq Ahmad and Pisany, 2023). Furthermore, the importance of following self-implied governance rules is stressed (Giudici and Adhami, 2019). Environmentally oriented start-ups receive more funding during ICOs coinciding with phases of high awareness of climate change and also have a higher chance of survival in the long term (Guzmán et al., 2020).

2.3. Underpricing

The literature on the success of ICOs mostly defines a measure that refers to the funding during the offering, such as reaching the soft or hard cap, or examining whether a token was listed after the ICO. The issue of underpricing arises after the completion of an ICO and its successful listing on a crypto exchange when the token starts trading on a secondary market. While the specific calculation of underpricing varies from paper to paper, underpricing can still be defined as the difference between the price of a token during the ICO and the price after the beginning of trading. A token is generally considered underpriced when its price in the funding stage is lower than after its listing. Chanson et al. (2018) calculated underpricing as the difference between the closing price after the first day of trading and the price during the ICO divided by the price during the ICO. By

analysing 95 ICOs using an ordinary least squares regression the authors find that activity on social discussion fora positively influences the level of underpricing. Analysing 825 ICOs, Varmaz and Varmaz (2018) report very high indirect costs for firms raising money by conducting an ICO in the form of underpricing. In the sample they process, they find mean values of underpricing of 435% in comparison with an average underpricing of 58% for tech firms that conducted an Initial Public Offering from 1980 to 2016. They state that not even in the high uncertainty hot markets preceding the burst of the dotcom bubble around the turn of the millennium IPO underpricing managed to come close to the level observed for ICOs today. Drobetz et al. (2019) find that the ICO market is strongly dependent on the overall crypto market sentiment but finds only very little dependence on the general capital market sentiment. Felix and von Eije (2019) define underpricing in the same way as Chanson et al. (2018). They obtained the trading data they used for assessing the first-day closing price from the coinmarketcap.com website. They analysed 279 ICOs that raised money between April 2013 and January 2018 and found average levels of underpricing of 129% in the USA and 97% in the other countries of their sample. They analysed some of the potential drivers of underpricing and found that the first-day trading volume, meaning how much tokens were traded on the first day after listing on coinmarketcap.com positively influenced underpricing. This may be explained by to higher demand on the first day driving up closing prices relative to the ICO price. Furthermore, they find that a positive sentiment on the ICO market in general results in higher underpricing for the tokens that got listed in such a period of positive awareness. Factors that negatively influence the underpricing after the first-day closing in their model are a large number of tradable tokens and the selling of tokens by the firm during a pre-ICO.

Another definition of underpricing is used by Lyandres et al. (2019). They define it as the ratio of the first-day opening price over the price during the ICO. They use quarterly time fixed effects, as well as region and industry fixed effects to control for the influence of those factors. They find that increasing bitcoin returns come with increasing underpricing, but cannot confirm this for all of their models, where in other specifications increasing Ether prices lead to decreasing under-pricing, while bitcoin prices are insignificant. Furthermore, they report a negative effect of the

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raised funds during the ICO on after-listing underpricing and argue that this is because large ICOs tend to be less obscure and suffer less from the information asymmetry problem. Moreover, by analysing 2131 ICOs between August 2015 and April 2018, Momtaz (2020) finds that the quality of the management team increases underpricing, and so does the following of the ERC20 standard, a standard protocol based on the Ethereum platform. Momtaz (2021), using the same sample, finds that enterprises with more loyal CEOs resort to less underpricing and obtain higher success rates of funding. He argues that the loyalty of CEOs reduces agency costs acting as an attractor for investors towards ICOs with such CEOs in the absence of effective mandatory corporate governance mechanisms.

Using a sample of 2665 ICOs of which 527 are listed, Florysiak and Schandlbauer (2022) employ textual analysis to assess the informativeness of a company's whitepaper. The latter can be classified into two types: standard, if it reports general and shallow information or fully informative, if it describes in detail information about the firm's business idea. They find that informative whitepaper content increases the level of underpricing, defined as in Benedetti and Kostovetsky (2021).

The publications discussed above use different measures for underpricing, using opening prices (Benedetti and Kostovetsky, 2021) or closing prices (Chanson et al., 2018) or examining the long-term performance of tokens after their listing (Lyandres et al., 2019). Most of the authors argue that information asymmetry is one of the defining features of the young ICO market. Mitigating this asymmetry can decrease the level of underpricing and thus the indirect costs that a venture raising capital through a token sale is facing (Varmaz and Varmaz, 2018). Some of the underpricing may be occurring for entrepreneurial purposes, as it is used as a signal of high quality by some firms conducting an ICO, enabling themselves to differentiate from less underpriced low-quality ICOs that cannot afford higher levels of underpricing during the ICO stage (Florysiak and Schandlbauer, 2022).

2.4. The influence of ESG orientation on underpricing

Literature on the influence of ESG criteria on ICOs in general is rather scarce. Some papers have dealt with the issue in the context of ICO success (Bitetto and Cerchiello, 2023). However, at the time of writing, there is no available research on ESG influence on ICO underpricing. Therefore, we examine the literature in the related field on IPO underpricing, as some recent studies shed light on the contribution of ESG on the issue. Shortly speaking, an IPO is the process of a once-private firm going public, selling their shares during an initial event, and the IPO at a set price to investors (Ibbotson and Ritter, 1995). The key difference between ICOs and IPOs is that there is a significantly better-developed regulatory framework involving necessary intermediaries surrounding IPOs. Still, past literature on ICO underpricing has found that many of the factors influencing IPO underpricing are also relevant in the domain of ICO underpricing (e.g., Benedetti and Kostovetsky (2021) that find that measures for information asymmetry influence IPO underpricing, similar to Rock (1986)). Cao et al. (2021) elaborate in their publication that the average investor takes ESG criteria into account when investing in the stock market and seeks socially responsible investment options both for the returns they yield and because of social responsibility reasons per se. These discoveries make it worthwhile to look at some of the recent findings of IPO underpricing literature regarding ESG orientation. Baker et al. (2021) examined 7446 IPOs in 36 countries and discovered that in countries with higher government ESG ratings, the underpricing tends to be lower. The authors find that this effect is especially impactful in countries with a more developed regulatory governance framework. Fenili and Raimondo (2021) state that disclosing more ESG information in the S1-filing (similar purpose to the whitepaper), reduces information asymmetry and thus as a consequence, underpricing for the US IPOs that they examine. The authors analyse those documents by using a keyword-based sentiment analysis approach. They furthermore find that the influence of ESG as a whole is higher than the influence of its parts - environmental, social and governance, respectively. Ferri et al. (2023) analysed 100 European firms that have conducted an IPO between 2017 and 2021. In essence, they confirm what Fenili and Raimondo (2021) found for US IPOs: that ESG disclosure before the IPO reduces information asymmetry and sub-

sequently underpricing. But, instead of analysing the S1-filing for ESG-related information, they check whether firms published a sustainability report before the IPO.

3. Motivation

Over the last few years, scholars managed to identify many potential drivers of ICO success and explored what influences the underpricing and long-term performance of listed tokens. Some researchers have already examined the influence of a start-up's ESG orientation on the success of its ICO (Bitetto and Cerchiello, 2023, Mansouri and Momtaz, 2022). Although there is no published research yet on how the ESG orientation of a firm influences the phenomenon of ICO underpricing, the recent IPO literature (Ferri et al., 2023) focuses on the issue and finds a significant negative influence of ESG-related variables on IPO underpricing. Thus, we can speculate that ICOs disclosing more information about their ESG orientation in their whitepapers should have, ceteris paribus, lower underpricing compared to ICOs that disclose less information - or are less ESG-oriented. Moreover, following the "Post-Funding Underperformance Hypothesis" of Mansouri and Momtaz (2022), we expect that a higher ESG score also has a negative effect on the longer-term returns of tokens. Another important question is whether the singular dimensions E (environment), S (social) and G (governance) can influence underpricing in the same way. As Fenili and Raimondo (2021) found, this is the case for IPO underpricing, thus we want to verify if this is true for ICO underpricing as well. Therefore, we test the following hypotheses:

H1a : *ICOs with a higher ESG score are less underpriced on the first day after listing.*

H1b : *ICOs with a higher ESG score experience less "long-term underpricing".*

H1c : *E, S and G scores reduce underpricing after listing.*

"Long-term underpricing" refers to the price of a token after 14 or 60 days of trading compared with its price during the ICO.

Moreover, we explore the influence of the whitepaper's length on the underpricing of tokens. The influence of content informativeness of whitepapers on underpricing has been assessed by Florysiak and Schandlbauer (2022), other authors stressed the importance of having a whitepaper for ICO success. Mansouri and Momtaz (2022) have found a positive influence of whitepaper length on the amount of funding a firm receives during the ICO. The question is whether the length of a whitepaper can serve as a useful proxy for informativeness, which would result in a reduction of information asymmetry with increasing whitepaper length and thus decreasing underpricing. Following the aforementioned authors' rationale, another possibility could be that information asymmetry increases with the length of the whitepaper as there could simply be more uninformative standard content present. This is why the direction of the effect - if present, is uncertain. Therefore, in our second hypothesis, we assume that there is an effect, but acknowledge, that the direction is uncertain. Therefore, we test the following hypotheses:

H2a : *The length of the whitepaper influences the short-term underpricing of ICO tokens after listing.*

H2b : *The length of the whitepaper influences the long-term underpricing of ICO tokens after listing.*

Finally, Lyandres et al. (2019) found that long-term post-ICO cumulative returns of tokens after 30 and 180 days are highly dependent on first-day (open to close) underpricing. Building on this result, we explore whether the level of underpricing on the first day in relation to the ICO price (ICO end to first-day closing underpricing) impacts the long-term underpricing. Lyandres et al. (2019) discovered that if first-day opening to closing returns are positive, this has a negative influence on longer-term post-ICO returns. We test whether a higher level of underpricing at the closing of the first day also leads to this depreciation of value, measured by 14-days and 60-days underpricing. This is equivalent to 14- and 60-days returns compared with the token price during the ICO. Therefore, we test the following hypotheses:

H3a : *Underpricing on the first day of trading compared with the ICO price influences longer-term underpricing after 14 days.*

H3b : *Underpricing on the first day of trading compared with the ICO price influences longer-term underpricing after 60 days.*

4. Data

To achieve robust and reliable results and, given the complexity and heterogeneity of the data sources, we drafted and implemented a protocol for scraping data from the website `ICOmarks.ai`, through Python Selenium. We downloaded 8279 data points comprising 7574 Initial Coin Offerings (ICO), 177 Security Token Offerings (STO) and 528 Initial Exchange Offerings (IEO). The collected information involves *details on ICO*, such as the Start/End Date, the Country in which the company is based on, the Website link, the presence of a Whitepaper, whether the ICO allows a Whitelist and Minimum Viable Product (MVP), if the ICO has Bounty and/or Bonus schema, the *ICO classification*, such as the Category the ICO can be classified into (Energy, Finance, Tech, Infrastructure), the *rating on ICOmarks*, the *Social Media statistics*, such as the social media on which the ICO advertisement takes place or where are the forums for interested people and investors, the *details of the Token*, such as its Ticker, the used blockchain Platform and Security Protocol, the token Amount available for sale and its Total Supply, the *Financial Statements*, such as the price of ICO's Token, which (crypto)-currency is accepted for trading, the Total of funds raised, Hard/Soft cap during the funding round, the *Team and Advisors size*. Given the focus of our analysis, we restricted the perimeter to ICO only and we downloaded all the related whitepapers, when available, and recovered the missing one by `archive.org/web/`. The raw downloaded data contained typos and numbers were reported in non-standard form (e.g. decimal or thousands separator) so a massive cleaning was performed as well as a conversion of ICO prices, reported in fiat or crypto units, to U.S. Dollars. For the conversion, we used the average FX rate of the month when the ICO started.

We were able to discover information about the industry, word count, degree of technical and

financial proficiency, and, most significantly, if the whitepaper adheres to ESG principles or contains a relevant business concept by processing the whitepaper. In order to parse the whitepaper and extract the required characteristics we use Deep Learning based techniques to perform textual analysis, such as Bidirectional Encoder Representations from Transformers (BERT) architecture (Devlin et al., 2019). In this phase, we used pre-trained models that are specialized in disclosing ESG- and Financial-related vocabularies (Huang et al., 2023). In particular, the model we selected is able to predict a probability score for each ESG class, i. e. Environmental, Social, and Governance, as well as the class "Non-ESG Related" returning an estimation of how relevant is the corresponding topic inside the whitepaper. Then, we convert the probabilities into a dummy *ESG* assigning the value of 1 if the combination of the three probabilities (E, S or G) is greater than the probability of the "Non-ESG Related" class. In addition, we evaluated the logarithm of word count in the whitepaper as a measure of information details.

The dependent variable is the underpricing after the ICO listing on the crypto exchange, evaluated as the ratio of the trading price and the ICO price during the funding round. In particular, we tested different time horizons when evaluating underpricing: the price on the first-day opening and closing, after 14 days and after 60 days. Prices are downloaded from coinmarketcap.com.

Moreover, the logarithm of GDP and the Rule of Law[2] rating are also included as a proxy for a country's economic development and the soundness of its legal system.

After screening for available whitepapers and relative ICOs with no missing data for the other variables of interest, we ended up with a database containing 471 ICOs, spanning from 2015 to late 2019. Table 1 and Figure A.4 in the Appendix present the summary statistics of the variables described in the previous section and their pairwise correlations, respectively.

The earliest ICO in the dataset started in August 2015, and the latest started on the 31st of March 2019. The left panel of Figure 1c shows that almost 50% of ICOs took place in 2018, 25% in 2017, 15% in 2019 and the peak of ESG-related ICOs is in 2018, with 79 start-ups. An increasing trend for the duration of the funding round can be seen in the right panel of Figure 1c.

[2]https://worldjusticeproject.org/rule-of-law-index/

Table 1

List of variables used in the analysis, the total number of non-missing observations and descriptive summary statistics. Variables' legend is reported in Section 4 of the main document.

| Variable	Description	Obs	Min	P25	Median	Mean	P75	Max
1 - UnderprOpen	Underpricing on 1st day open price	471	0	0.27	0.73	1.67	1.59	64.29
2 - UnderprClose	Underpricing on 1st day close price	471	0	0.28	0.76	1.73	1.66	57.46
3 - Underpr14	Underpricing after 14 days	460	0	0.25	0.53	1.8	1.42	110.08
4 - Underpr60	Underpricing after 60 days	463	0	0.2	0.47	1.81	1.3	110.08
5 - ESG	Dummy for presence of ESG topics in the whitepaper	471	0	0	0	0.25	1	1
6 - E	Percentage of Environmental topics in the whitepaper	471	0	0.14	0.28	0.33	0.42	0.93
7 - S	Percentage of Social topics in the whitepaper	471	0	0.23	0.35	0.37	0.47	0.89
8 - G	Percentage of Governance topics in the whitepaper	471	0.01	0.19	0.31	0.34	0.46	0.96
9 - log(Price)	Logarithm of price during funding round	471	-4.1	-1.65	-1.03	-1.11	-0.49	1.19
10 - log(NWords)	Logarithm of number of words in the whitepaper	471	2.78	3.54	3.69	3.66	3.83	4.15
11 - TeamSize	Size of the start-up team	471	1	7	10	11.43	13	58
12 - AdvisorSize	Number of advisors	471	0	0	4	4.58	7	22
13 - SocialCount	Number of social media	471	0	5	7	6.66	8	11
14 - PreSaleDummy	Dummy for presence of pre-sale round	471	0	0	0	0.29	1	1
15 - ERC20Dummy	Dummy for presence of ECR20 protocol	471	0	0	1	0.72	1	1
16 - KYCDummy	Dummy for presence of Know Your Customer	471	0	0	0	0.42	1	1
17 - BonusDummy	Dummy for presence of bonus schema	471	0	0	0	0.13	0	1
18 - BountyDummy	Dummy for presence of bounty schema	471	0	0	0	0.24	0	1
19 - log(GDPYearly)	Logarithm of Annual GDP	471	8.7	11.55	11.84	11.85	12.46	13.37
20 - RuleofLawYearly	Rule of Law Index	471	-1.63	1	1.62	1.2	1.79	1.92

In terms of the geographic distribution of ICOs, 40% of ICOs have a start-up based in Europe, 30% in Asia, and 20% in North America, as shown in Figure 1b, and the distribution of ESG-related ICOs is homogeneous among the top three regions. In Europe, the country with the most ICOs is Switzerland, with 43 ICOs, followed closely by the United Kingdom with 42. In Asia, most ICOs were held in Singapore (69), followed by Hong Kong with 23. In North America, most offerings took place in the United States (62) and the second most in the Cayman Islands (12). The ICOs are also classified into the seven largest industrial categories and each start-up can belong to more than one category. Smaller categories are summarised under the category "Other". The assignment of categories is done by analysing the whitepaper, the largest category being "Tech" with 318 of the enterprises being sorted into it. Figure 1a, shows that the "Tech" category is followed by "Finance" with 227 start-ups. The smallest two categories not summarised under the category "Others" were "Energy" with 10 occurrences and "Manufacturing". As for the geographical distribution, the percentage of ESG-related start-ups is similar in the most populated categories.

Focusing on the different specifications of the underpricing, ICOs in the last half of the distribution are overpriced, meaning that their price on the first day of trading drops lower than it was
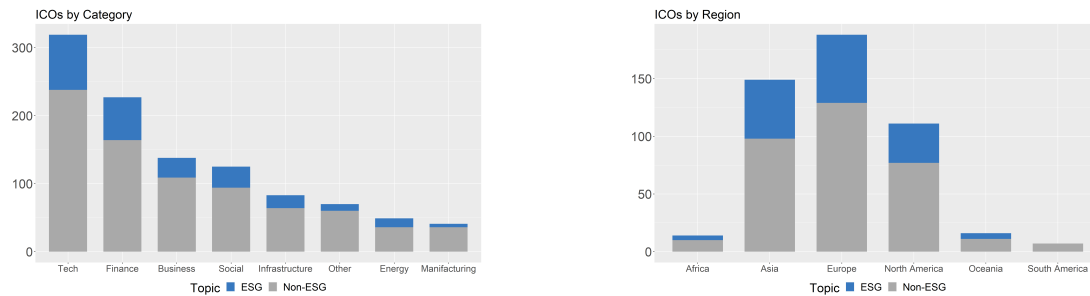
(a) ICOs over categories.

(b) ICOs over regions.
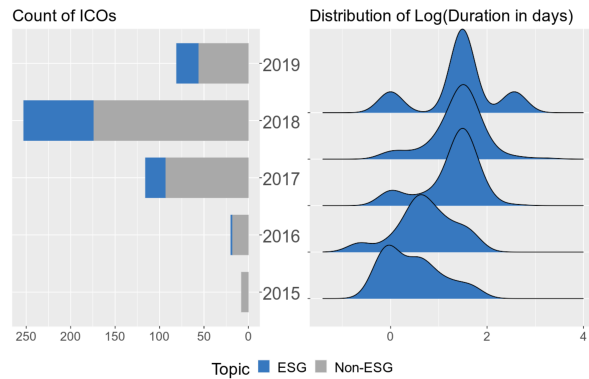

(c) ICOs over years.

Fig. 1. Descriptive statistics for ICOs and ESG-related topics. Fig. 1a reports the distribution of ICOs over the industrial classification of the start-up, each start-up can belong to more than one category. Fig. 1b reports the distribution of ICOs over the region in which the start-up is based. Fig. 1c reports the distribution of ICOs over the year in which the founding round started. For each figure, the blue areas represent the ESG-related start-ups, the grey areas the remaining ones.

during the Initial Coin Offering event, as shown in Table 1. However, assuming that an investor invested the same amount of money in all of the firms of the sample during their ICOs, he can already expect profits when liquidising his portfolio on the first day of trading, as the average ICO in the sample is underpriced. The mean returns on the 1st-day opening of the market are already highly positive, as the investor with the aforementioned portfolio could already expect 67% of profit when liquidising. Nevertheless, waiting is profitable: postponing the liquidation only until the end of the first day of trading already comes with an increase in profits, an investor pursuing this strategy could have expected 72% of profit. Moreover, the other statistics in Table 1 for the first day reveal that all of them – except the minimum and maximum – are also rising, further indicating that waiting on the first day is worthwhile. Furthermore, when looking at the long-term returns after 14 and 60 days, one can see that average returns / underpricing increases even more.

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Momtaz (2020) has found that average first-day returns, measured by the difference of 1st-day opening price and 1st-day closing price, lie between 6.8% and 8.2% in their sample and median 1st-day returns lie between 2.6% and 3.4%. In our sample, the mean 1st-day returns are 5.33% and median 1st-day returns are 2,78%. Figure 2a reports the boxplot of the different specifications for underpricing comparing the ESG-related start-ups (in blue) with the Non-ESG-related ones and clearly shows that the underpricing is less prominent in the ESG-related ones. Moreover, other authors have already found that underpricing seems to be reduced over time, meaning that levels of underpricing for ICOs in 2017 are on average higher than for example in 2018 (Benedetti and Kostovetsky, 2021). Figure 2b depicts the same phenomenon, showing an overall decreasing trend and still highlighting the mitigation of underpricing for ESG-related start-ups. Figure 2c reports the underpricing for tokens in each geographical region and shows that mean underpricing is highest in Europe after 14 days, followed by Asia and North America after 60 days. Median levels of underpricing in Europe and Asia are highest after 1st-day closing, whilst being highest directly after 1st-day opening in North America.

5. Methodology and results

We fit several models based on ordinary least squares regression to test the hypotheses in Section 3. All model specifications include independent variables such as the logarithm of PriceUSD during the ICO and the logarithm of the whitepaper length, as well as the presence of a pre-sale, Bounty and Bonus schema, ERC20 protocol, Know Your Customer procedure and the number of social media channels the firm is active on. Moreover, we include the size of the company's team, the number of advisors, the logarithm of GDP and the Rule of Law rating. In all models, we control for time, by including quarterly fixed effects, for industry, by including industry category fixed effects and for geographic distribution by including country fixed effects. A comparison with the models without any fixed effect is also included. For hypotheses 1(a, b, c) and 2(a, b), we define a model that includes the ESG score and the single E, S, and G scores, and we vary the dependent variable with the underprice at the first-day open and close, after 14-days and 60-days. For hypoth-

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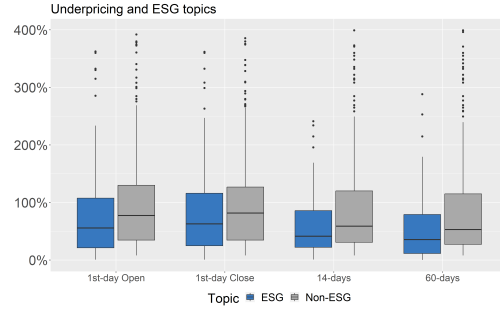
(a) Underpricing in ESG and Non-ESG related ICOs.
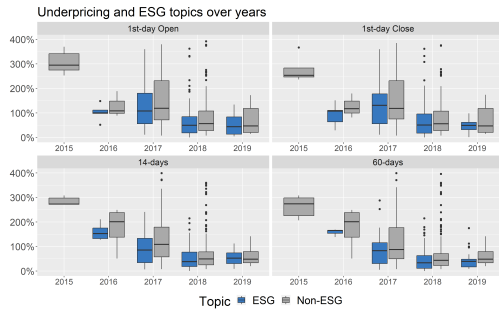
(b) Underpricing in ESG and Non-ESG related ICOs by years.
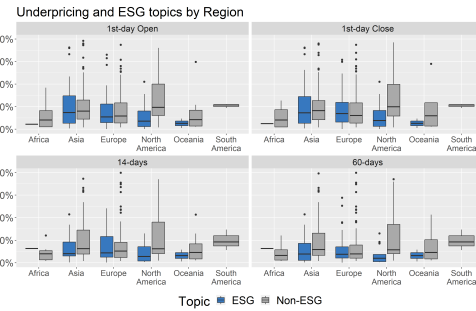
(c) Underpricing in ESG and Non-ESG related ICOs by Region.

Fig. 2. Boxplot of different specifications of underpricing, defined with respect to the 1st-day Open and Close price and after 14 and 60 days. Fig. 2a reports the comparison of underpricing between ESG-related (in blue) start-ups and the Non-ESG-related ones (in grey). Fig. 2b expands the analysis over the years and Fig. 2c expands the analysis by Region.

esis, 3 we keep all previous independent variables, we add the logarithm of the underpricing of the first-day closing price and we vary the dependent variable with the underprice after 14-days and 60-days. Moreover, we perform a sensitivity test transforming the continuous underpricing variable into a binary one, for each of the four specifications: if the value is greater than the median we assign 1, 0 otherwise. Finally, we apply dominance analysis (Luchman et al., 2020) to prove the dominant role of ESG flag as a predictor in our regression task.

Table 2 reports the results of OLS regression when predicting the underpricing, in each of the four specifications, with the ESG binary flag as regressor. The results in columns (1)-(4) support hypothesis 1a, that a higher ESG score decreases underpricing directly after listing. The negative and statistically significant coefficients in both models prove that being a start-up that deals with ESG-related topics leads to an approximate 2.5% decrease in underpricing when examining both underpricing after opening and after first-day closing. This indicates that the effect of disclosing

the underpricing in the S1-filing, namely a mitigation of information asymmetry and a following reduction in underpricing for US IPOs, found by Fenili and Raimondo (2021), translates to the domain of ICOs and whitepapers. Thus, hypothesis 1a is not rejected. The same results hold for columns (5)-(8) for the underpricing after 14 and 60 days since the end of the funding round. Therefore, hypothesis 1b, which states that the presence of ESG-related topics should decrease the long-term underpricing is not rejected either.

Table 3 reports the results of OLS regression when predicting the underpricing, in each of the four specifications, with the single E, S, and G scores, i.e. probabilities, as regressors. The overall outcome of the analysis confirms what has already been found for hypotheses 1a and 1b. The single dimensions for E, S and G still decrease the effect of underpricing, both in the short- and long-term. In particular, the decreasing effect of Environmental topics is quite strong regardless of the time horizon, whilst Social and Governance mitigate in a more prominent way only the long-term underpricing. Therefore, hypothesis 1c, which states that E, S and G scores reduce underpricing after listing, is not rejected.

Results in Tables 2 and 3 show, that there is a positive effect of whitepaper length on underpricing, meaning that underpricing seems to be increasing along with the increase of whitepaper length. The positive influence is statistically significant and moderate in magnitude in the short-term and 3-4 times higher in the long-term. The rationale behind this effect is not entirely clear, however, it may indicate that the whitepapers contain a higher amount of "standard information" and not substantially informative content, which, following Florysiak and Schandlbauer (2022), increases underpricing. Therefore, both hypotheses 2a and 2b, stating that the whitepaper length influences short- and long-term underpricing, respectively, are not rejected.

Table 4 reports the results of OLS regression when predicting the underpricing after 14 and 60 days only, with the ESG binary flag and the logarithm of the underpricing of the first-day closing price as regressors. Results show that the coefficients for the underpricing on the closing of the first day are all statistically significant and positive, indicating that the increase of the price on the first day in relation to the ICO price persists over a larger timeframe. This suggests that prices do not

Table 2
Predicting underpricing with OLS model through ESG dummy variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent				Underpricing				
Variable	1st-day Open		1st-day Close		14 days		60 days	
ESG	-2.457**	-2.254***	-2.086*	-2.633**	-1.717*	-1.302**	-2.251*	-2.957**
	(0.723)	(0.467)	(1.108)	(0.800)	(0.938)	(0.461)	(1.309)	(1.205)
log(Price)	-0.320*	-0.770**	-0.0313	-0.696*	-0.535**	-0.740***	-0.426*	-0.569**
	(0.174)	(0.271)	(0.166)	(0.246)	(0.202)	(0.268)	(0.241)	(0.277)
log(NWords)	0.387*	0.692**	0.549*	0.754**	2.316*	2.050**	2.484*	2.807**
	(0.160)	(0.196)	(0.288)	(0.212)	(0.913)	(0.627)	(0.973)	(0.752)
TeamSize	-0.0178	-0.0494	-0.0164	-0.0502	-0.0170	-0.0267	-0.00465	-0.0521
	(0.0372)	(0.0382)	(0.0368)	(0.0356)	(0.0497)	(0.0456)	(0.0433)	(0.0390)
AdvisorSize	-0.0544	-0.0145	-0.0665	-0.0363	-0.0859	-0.0315	-0.112	-0.0571
	(0.0461)	(0.0519)	(0.0439)	(0.0448)	(0.0887)	(0.0524)	(0.0928)	(0.0612)
SocialCount	-0.181	-0.119	-0.167	-0.115	-0.418	-0.329	-0.425	-0.318
	(0.179)	(0.216)	(0.176)	(0.215)	(0.381)	(0.408)	(0.382)	(0.387)
PreSaleDummy	-1.008**	-0.556	-0.984**	-0.460	-0.642**	-0.315	-0.699**	-0.589
	(0.484)	(0.602)	(0.464)	(0.596)	(0.312)	(0.690)	(0.342)	(0.925)
ERC20Dummy	1.905*	1.770	1.810*	1.610	1.803*	1.247	1.545	0.676
	(1.059)	(1.344)	(1.006)	(1.253)	(0.994)	(0.824)	(1.047)	(0.756)
KYCDummy	0.126	0.340	0.133	0.450	1.305***	0.0407	1.469***	0.0336
	(0.731)	(0.505)	(0.664)	(0.490)	(0.468)	(0.626)	(0.470)	(0.719)
BonusDummy	-0.431	-0.354	-0.420	-0.340	-0.423	-0.163	-0.450	-0.351
	(0.395)	(0.450)	(0.370)	(0.450)	(0.314)	(0.469)	(0.449)	(0.607)
BountyDummy	0.609	0.590	0.444	0.467	0.00580	0.293	0.134	0.133
	(0.839)	(0.770)	(0.764)	(0.702)	(0.436)	(0.434)	(0.448)	(0.415)
log(GDPYearly)	-0.0632	-0.150	-0.0509	-0.314	-0.0604	-0.128	-0.0835	-0.350
	(0.179)	(0.373)	(0.181)	(0.352)	(0.210)	(0.468)	(0.246)	(0.599)
RuleofLawYearly	-0.358	-0.698*	-0.373*	-0.708*	-0.702*	-0.0559	-0.634	-1.318**
	(0.212)	(0.398)	(0.220)	(0.392)	(0.374)	(0.423)	(0.386)	(0.585)
Observations	471	471	471	471	460	460	463	463
R^2	0.068	0.213	0.069	0.221	0.076	0.345	0.075	0.360
Quarter-Year effects	No	Yes	No	Yes	No	Yes	No	Yes
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Category effects	No	Yes	No	Yes	No	Yes	No	Yes
Clustered Std. Err.	Country	Country	Country	Country	Country	Country	Country	Country

Notes: The table reports coefficients and their standard error (in parentheses). The outcome variable is the continuous variable for underpricing in four different specifications. All variables are defined in Tab. 1. Data span over the period 2015-2019. The estimation method is OLS with standard errors clustered by ICO's country. The bottom part of the table reports which fixed effects are used in each model specification. The *, ** and *** symbols denote the p-values at 10th, 5th and 1st significance level, respectively.

fluctuate dramatically in the longer term and are largely explained by the happenings on the first day of trading. Also, the coefficient of the token price during the ICO is statistically significant and negative, indicating that higher ICO token prices result in lower longer-term underpricing. Therefore, both hypotheses 3a and 3b, which state that the underpricing on the listing day (relative

Table 3
Predicting underpricing with OLS model through E, S and G probability variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent				Underpricing				
Variable	1st-day Open		1st-day Close		14 days		60 days	
E	-9.650*	-36.32**	-11.53*	-36.51**	1.551*	-19.17**	-1.154*	-20.13**
	(3.643)	(12.29)	(4.499)	(10.75)	(0.827)	(7.32)	(0.861)	(8.46)
S	-4.701*	-2.715**	-0.791	-5.556**	-22.52*	-12.42**	-21.89	-17.99**
	(2.103)	(0.876)	(15.83)	(3.72)	(10.09)	(5.33)	(32.00)	(8.05)
G	-3.030	-2.162*	-1.332*	-1.371**	-17.50*	-18.07**	-13.36	-13.89**
	(14.85)	(0.583)	(0.782)	(0.376)	(8.750)	(5.76)	(22.10)	(6.26)
log(Price)	-0.0245	-0.798**	-0.178	-0.107**	-0.565**	-0.758**	-0.450*	-0.581*
	(0.185)	(0.275)	(0.176)	(0.051)	(0.239)	(0.287)	(0.265)	(0.290)
log(NWords)	0.306	0.572**	0.414*	0.614**	2.499*	2.075**	2.667*	2.861**
	(1.421)	(.149)	(0.193)	(0.288)	(1.023)	(0.793)	(1.011)	(0.924)
TeamSize	-0.0196	-0.0493	-0.0179	-0.0497	-0.0132	-0.0311	-0.00771	-0.0565
	(0.0399)	(0.0396)	(0.0395)	(0.0376)	(0.0565)	(0.0494)	(0.0495)	(0.0414)
AdvisorSize	-0.0601	-0.0181	-0.0706	-0.0382	-0.100	-0.0468	-0.125	-0.0736
	(0.0519)	(0.0554)	(0.0504)	(0.0487)	(0.106)	(0.0574)	(0.109)	(0.0691)
SocialCount	-0.186	-0.132	-0.174	-0.129	-0.417	-0.342	-0.423	-0.331
	(0.176)	(0.221)	(0.174)	(0.221)	(0.379)	(0.413)	(0.382)	(0.395)
PreSaleDummy	-1.015**	-0.549	-0.996**	-0.452	-0.608*	-0.332	-0.668*	-0.605
	(0.483)	(0.603)	(0.464)	(0.598)	(0.353)	(0.695)	(0.384)	(0.933)
ERC20Dummy	1.942*	1.901	1.848*	1.741	1.828*	1.337	1.566	0.753
	(1.083)	(1.387)	(1.027)	(1.286)	(1.044)	(0.825)	(1.104)	(0.759)
KYCDummy	0.0672	0.418	0.0728	0.526	1.246***	0.00507	1.427***	0.0764
	(0.746)	(0.526)	(0.678)	(0.516)	(0.396)	(0.598)	(0.415)	(0.697)
BonusDummy	-0.387	-0.277	-0.373	-0.263	-0.381	-0.0884	-0.416	-0.285
	(0.383)	(0.443)	(0.362)	(0.444)	(0.288)	(0.490)	(0.461)	(0.589)
BountyDummy	0.613	0.574	0.454	0.452	0.0611	0.357	0.173	0.180
	(0.836)	(0.757)	(0.758)	(0.690)	(0.398)	(0.436)	(0.432)	(0.395)
log(GDPYearly)	-0.0413	-0.131	-0.0345	-0.304	-0.0129	-0.0329	-0.0403	-0.450
	(0.174)	(0.403)	(0.176)	(0.384)	(0.180)	(0.577)	(0.229)	(0.709)
RuleofLawYearly	-0.362	-0.624	-0.375	-0.628	-0.715*	-0.0414	-0.646	-1.316**
	(0.216)	(0.409)	(0.224)	(0.409)	(0.386)	(0.418)	(0.402)	(0.644)
Observations	471	471	471	471	460	460	463	463
R^2	0.069	0.216	0.070	0.224	0.081	0.348	0.078	0.363
Quarter-Year effects	No	Yes	No	Yes	No	Yes	No	Yes
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Category effects	No	Yes	No	Yes	No	Yes	No	Yes
Clustered Std. Err.	Country	Country	Country	Country	Country	Country	Country	Country

Notes: The table reports coefficients and their standard error (in parentheses). The outcome variable is the continuous variable for underpricing in four different specifications. All variables are defined in Tab. 1. Data span over the period 2015-2019. The estimation method is OLS with standard errors clustered by ICO's country. The bottom part of the table reports which fixed effects are used in each model specification. The *, ** and *** symbols denote the p-values at 10th, 5th and 1st significance level, respectively.

to the ICO Price) is negatively impacting short- and long-term underpricing, respectively, are not rejected. In this setting, all previously tested hypotheses still hold.

In all previous models, the remaining control variables show consistent behaviour. In particular, the ERC20-Dummy variable, has a positive effect, in agreement with Momtaz (2020), that report a positive effect of adhering to the ERC20 standard on the level of underpricing. The logarithm of the price during the ICO has a strong and statistically significant negative effect on underpricing, supporting the results found by Benedetti and Kostovetsky (2021), who found the same to be true in their analysis. However, in contrast to their finding, the Rule of Law rating of a country significantly influences underpricing in a negative way. This may be due to the fact that it captures how the country's legal environment is perceived by investors. Countries with better systems may act as builder of trust when investing in volatile and novel start-up tokens through an ICO. Baker et al. (2021) found that higher country-level ESG ratings reduce the underpricing of IPOs, so the significance of the Rule of Law rating may indeed indicate that investors pay attention to country-level governance when making investment decisions in the ICO market.

Moreover, Table 5 reports the results of the sensitivity analysis for the robustness of the previous findings. In particular, we transform the continuous target variable of underpricing, in each of the four specifications, into a binary flag, 1 if the value is greater than the median and 0 otherwise, and we regress it against the ESG binary flag using a Logit model. The results confirm all hypotheses.

Finally, in order to further prove the key role of the ESG flag when predicting the outcome Underpricing, we apply dominance analysis. The relative importance of each regressor in a statistical model is the focus of the dominance analysis (Azen and Budescu, 2006). In particular, the Shapley value decomposition from game theory is used to evaluate the relative importance of the independent variables based on the individual contribution to the prediction performance, comparing a specific fit statistic. Indeed, the importance is determined by assessing the magnitude of the reduction in the prediction error caused by the single regressor (Luchman et al., 2020). In our case, the dominance fit statistic represents the average net increase in the R^2 of the model resulting from adding an independent variable to models that include all possible subsets of the other regressors. Figure 3 reports the results for the previous three models, (a) predicting Underpricing with ESG

flag, (b) with ESG flag and logarithm of the underpricing of the first-day closing price, and (c) with E, S, G probabilities. ESG and E, S, G are the most relevant variables, accounting for 40 % of the overall prediction performance in model (a). Such effect is slightly mitigated when including the logarithm of the underpricing of the first-day closing price.
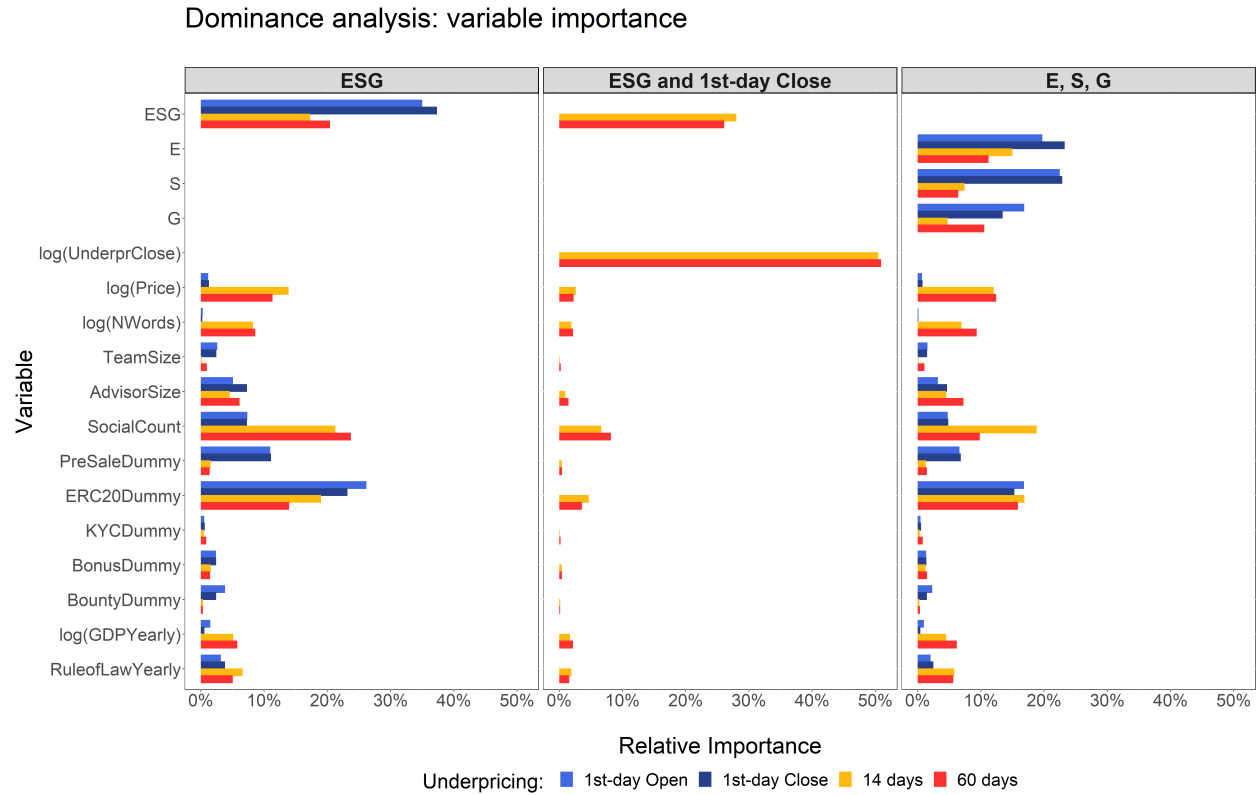
Fig. 3. Dominance analysis to assess the relative importance of each regressor when predicting Underpricing in four different specifications. Results are reported for three models, predicting Underpricing with ESG flag, with ESG flag and logarithm of the underpricing of the first-day closing price, and with E, S, G probabilities. Percentages show the relative contribution of each regressor to the overall R^2.

6. Conclusion

In this paper, we explore the nexus between the attention of an Initial Coin Offering to Environmental, Social and Governance (ESG) topics and the phenomenon of its underpricing after the funding round. According to our definition, underpricing occurs when the price of the ICO's token is lower than the one traded on the market.

We contribute to the research field by investigating whether attention to ESG topics may reduce underpricing when the start-up deals with ESG topics, especially in the long run. To this aim, we

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leverage Natural Language Processing tools, based on recent Artificial Intelligence techniques, to evaluate the pertinence of ICO's whitepaper to ESG subjects and to estimate the relative probability of each single dimension E, S and G. These probabilities are used, in addition to other independent and control variables, to predict the underpricing at different time horizons, i.e. at first-day open and close price and after 14 or 60 days. Underpricing is evaluated as the ratio of the trading price and the ICO price during the funding round.

Our analysis supports the main hypothesis. In line with recent Initial Public Offering (IPO) literature (Fenili and Raimondo, 2021, Ferri et al., 2023) we prove a negative relationship between higher ESG scores and underpricing. This fills the gap between the results found in the IPO underpricing literature and the ICO literature. Our results indicate that start-ups with a higher ESG orientation raising capital through ICOs tend to suffer less from underpricing on the first day of trading compared to lower or non-ESG start-ups, both after the opening and the closing of the trading day.

Further, we found that an increase in the length of the whitepaper goes along with an increase in underpricing, both in the short and longer run and that underpricing at the closing of the first day positively influences long-term returns, both after 14 and 60 days.

However, there are some important limitations of this work, that must be stressed. First of all, the size of the usable sample of ICOs is rather small. Despite the capability of putting in place a protocol for collecting a wide, comprehensive and wide database of ICOs, the main bottleneck consists of the limited availability of whitepapers and trading prices. Such bottlenecks can be mitigated in the future by increasing the quality of data sources (public platforms) and possibly by a legislation that imposes disclosure of whitepapers and other relevant information to ICO issuers.

The importance of ESG topics is undisputed and the awareness around climate change, social justice and regulatory frameworks is constantly gaining relevance to regulators and policy-makers. In this regard, we contribute to the debate by extending the attention from the IPOs underpricing phenomenon to the similar one occurring in ICOs, with a specific emphasis on those undertaking ESG-related actions. Decision-makers need to be fueled with robust and data-driven evidence to

influence and shape a still unregulated market, that anyhow attracts many investors. Future research should expand on those findings and test their validity on larger samples including data on more recent and more ESG-oriented ICOs.

Funding

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Table 4

Predicting long-term underpricing with OLS model through ESG dummy variable and underpricing on 1st-day close price.

	(1)	(2)	(3)	(4)
Dependent		Underpricing		
Variable	14 days		60 days	
ESG	-1.663*	-4.170**	-2.376*	-1.592**
	(0.913)	(1.847)	(1.395)	(0.734)
log(UnderprClose)	3.168***	2.698***	3.143***	2.552**
	(1.100)	(0.961)	(1.085)	(0.943)
log(Price)	-0.108	-0.334*	-0.0115	-0.188**
	(0.177)	(0.197)	(0.224)	(0.091)
log(NWords)	1.164	0.735	1.388	1.627
	(1.781)	(2.221)	(1.845)	(2.270)
TeamSize	-0.0203	-0.0164	-0.000546	-0.0422
	(0.0485)	(0.0406)	(0.0418)	(0.0321)
AdvisorSize	-0.0388	-0.0364	-0.0642	-0.00704
	(0.0691)	(0.0510)	(0.0733)	(0.0567)
SocialCount	-0.414	-0.332	-0.421	-0.318
	(0.367)	(0.393)	(0.368)	(0.372)
PreSaleDummy	-0.123	-0.631	-0.0856	-0.892
	(0.450)	(0.755)	(0.494)	(0.999)
ERC20Dummy	1.115	0.908	0.841	0.336
	(0.726)	(0.725)	(0.776)	(0.643)
KYCDummy	0.776***	0.0246	0.953***	0.0279
	(0.280)	(0.574)	(0.280)	(0.668)
BonusDummy	-0.331	-0.0473	-0.369	-0.150
	(0.383)	(0.539)	(0.516)	(0.646)
BountyDummy	0.352	0.396	0.213	0.242
	(0.489)	(0.440)	(0.508)	(0.441)
log(GDPYearly)	-0.233	-1.085	-0.244	1.474
	(0.264)	(0.776)	(0.294)	(0.877)
RuleofLawYearly	-0.593*	-1.085	-0.530*	-0.330
	(0.297)	(0.691)	(0.295)	(0.605)
Observations	460	460	463	463
R^2	0.164	0.395	0.154	0.401
Quarter-Year effects	No	Yes	No	Yes
Country effects	No	Yes	No	Yes
Category effects	No	Yes	No	Yes
Clustered Std. Err.	Country	Country	Country	Country

Notes: The table reports coefficients and their standard error (in parentheses). The outcome variable is the continuous variable for underpricing in four different specifications. All variables are defined in Tab. 1. Data span over the period 2015-2019. The estimation method is OLS with standard errors clustered by ICO's country. The bottom part of the table reports which fixed effects are used in each model specification. The *, ** and *** symbols denote the p-values at 10th, 5th and 1st significance level, respectively.

Table 5

Predicting binary flag for underpricing with Logit model through ESG dummy variable.

	(1)	(2)	(3)	(4)
Dependent		Binary flag for Underpricing		
Variable	1st-day Open	1st-day Close	14 days	60 days
ESG	-5.092**	-6.447**	-3.267**	-6.129**
	(2.167)	(2.629)	(1.419)	(2.718)
log(Price)	-0.647***	-0.487***	-0.685***	-0.637***
	(0.137)	(0.150)	(0.186)	(0.185)
log(NWords)	1.321*	0.876**	0.217*	0.568*
	(0.701)	(0.345)	(0.121)	(0.235)
TeamSize	-0.00109	-0.000203	-0.0122	-0.0144
	(0.0265)	(0.0266)	(0.0159)	(0.0187)
AdvisorSize	-0.126***	-0.113***	-0.114***	-0.113***
	(0.0257)	(0.0238)	(0.0305)	(0.0333)
SocialCount	-0.00640	-0.00541	-0.0760	-0.0664
	(0.0785)	(0.0722)	(0.121)	(0.105)
PreSaleDummy	-0.477**	-0.271	-1.091***	-0.320
	(0.242)	(0.201)	(0.260)	(0.320)
ERC20Dummy	0.842***	0.564**	1.178***	0.576**
	(0.272)	(0.248)	(0.308)	(0.265)
KYCDummy	0.133	0.0131	0.195	0.172
	(0.337)	(0.386)	(0.340)	(0.419)
BonusDummy	-0.337	-0.150	-0.114	-0.391
	(0.560)	(0.479)	(0.593)	(0.467)
BountyDummy	0.448	0.106	0.459	0.463
	(0.425)	(0.458)	(0.369)	(0.382)
log(GDPYearly)	-0.831***	-1.295***	-2.060***	-0.990***
	(0.207)	(0.164)	(0.336)	(0.193)
RuleofLawYearly	-0.323	-0.274	-0.709***	-0.762***
	(0.314)	(0.298)	(0.255)	(0.249)
Observations	471	471	460	463
Pseudo R^2	0.273	0.240	0.307	0.295
Quarter-Year effects	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes
Category effects	Yes	Yes	Yes	Yes
Clustered Std. Err.	Country	Country	Country	Country

Notes: The table reports coefficients and their standard error (in parentheses). The outcome variable is the binary variable for underpricing, where 1 is for values greater than the median, 0 otherwise, in four different specifications. All variables are defined in Tab. 1. Data span over the period 2015-2019. The estimation method is the Logit model with standard errors clustered by ICO's country. The bottom part of the table reports which fixed effects are used in each model specification. The *, ** and *** symbols denote the p-values at 10th, 5th and 1st significance level, respectively.

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Appendix A. Correlation matrix
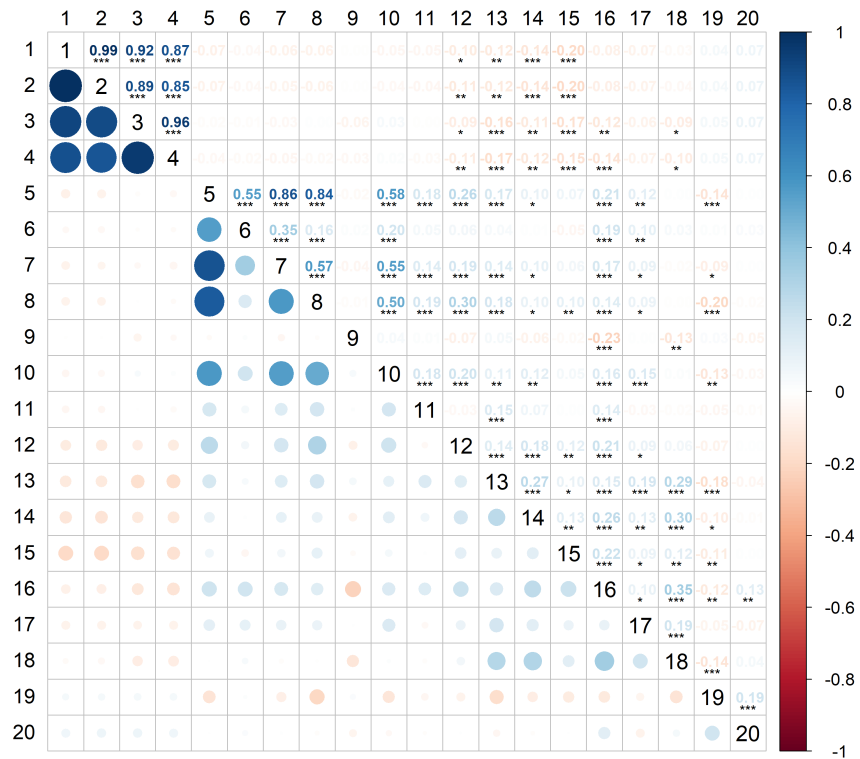
Fig. A.4. Correlation matrix of dependent and independent variables. P-values significance level for each correlation coefficient is reported with the following legend: $*$ if $p < 0.1$, $**$ if $p < 0.05$, $***$ if $p < 0.01$. Variables' legend is reported in Table 1 of the main document.