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To Tweet or not to Tweet? The Determinants of Tweeting Activity in Initial Coin Offerings

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Our research explores the causes of Twitter activity in highly technological start-ups that finance their activities via initial coin offerings (ICOs). By relying on weekly data of 297 ICOs for the period 2015–2020 (35,459 observations), we examine how major exogenous events affect the number of tweets issued by the start-up. Then, we explore how the community of followers reacts to the tweets. We discover that events external to firms reduce ICOs' tweeting activity. Moreover, our evidence indicates that the followers' reaction is positively related to the tweets issued by the firm and negatively related to major events unrelated to the firm. Interestingly, followers' reaction has an inverted U-shaped relation with the firm's Twitter volume, suggesting that excessive Twitter activity can harm the further dissemination of tweets. Our results, robust to alternative estimation techniques, emphasize the important role of Twitter as an information disseminator, legitimizer, and endorser for highly opaque firms.

Introduction

With the development of the Internet, computer networks, and social media, new ways of financing have emerged such as reward crowdfunding, equity crowdfunding, peer-to-peer lending (Ahlers *et al.*, 2015; Belleflamme *et al.*, 2014; Shi, 2018), and very recently initial coin offerings (ICOs) (Adhami *et al.*, 2018; Bellavitis *et al.*, 2021; Fisch, 2019). These innovative financing tools allow entrepreneurs to directly tap into the crowd, bypassing intermediaries so that the entrepreneur can access funds at lower costs (no fees and reduced red tape). In addition, these tools allow the crowd to take direct decisions (and related responsibility) about how to invest their savings, and because of the minimal investment request, they are considered very democratic and open to everyone (Chen, 2018; Fink *et al.*, 2020; Mollick, 2014; Nakamoto, 2008).

Among the quoted innovative financing tools, the most recent one (which, in some way, builds on initial public offerings, crowdfunding, and peer-to-peer lending) is the ICO, which is defined as the process of selling tokens that give access either to a share of the future cash flow generated by the venture (security token) or to a service provided by the venture (utility token).

ICOs have some peculiar characteristics. First, they are used to finance projects characterized by extreme uncertainty (Bellavitis, Fisch and Wiklund, 2021; Narayanan *et al.*, 2016), and often by the development of completely new products and services not currently available in the market, meaning that there is implied uncertainty even about whether there is a market for the product/service offered. Thus, it is very difficult to know whether the project will be successful (Chen, 2018, 2019) and, similarly to projects financed by business angels and venture capitalists (Cressy, 2006), the common expectation is that only a very small number of ICOs will survive and succeed (Bellavitis *et al.*, 2021). Second, token issuers directly address a large crowd of potential investors, and the sale is managed by the token issuer on their website without intermediaries. Moreover, tokens issued during the ICO period can be defined as cryptoassets (Corbet *et al.*, 2019; Kajtazi and Moro, 2019) as they may be also traded on platforms that act as secondary markets (Corbet *et al.*, 2019; Fisch, 2019; Jackson, 2018; Kajtazi and Moro, 2019; Moro and Wang, 2020). All in all, investors are expected to make investment decisions without any support provided by professional intermediaries during both the upfront screening stage and the post-investment monitoring stage (Diamond, 1984); therefore, they have to make up their minds by relying on the information disseminated by the firm and the information accessible in the public domain (Ante *et al.*, 2018; Domingo *et al.*, 2020).

In such a context, ICO issuers may leverage social media to maximize and optimize information sharing and, more importantly, to gain legitimization (Risius and Beck, 2015; Sprenger *et al.*, 2014; Sul *et al.*, 2017), as shown by some empirical evidence (Adhami and Giudici, 2019; Benedetti and Kostovetsky, 2021; Block *et al.*, 2020; Domingo *et al.*, 2020; Fisch, 2019; Gartner *et al.*, 2021; Kim *et al.*, 2016; Moro and Wang, 2020; Roosenboom *et al.*, 2020; Samieifar and Baur, 2021; Sheng *et al.*, 2017; Yadav, 2017).

However, irrespective of the accepted role of social media as a cause of the success of an ICO (Goodell *et al.*, 2022), currently very little is known about the determinants/strategies of the dissemination of information via social media. Our work, by building on current research on cryptoassets and Twitter activity (Benedetti and Kostovetsky, 2021; Karalevicius *et al.*, 2018; Perez *et al.*, 2020; Sprenger *et al.*, 2014), digs into the very marginally investigated area of the determinants of the use of social media, addressing the following two major questions. (1) How is the ongoing conversation between the firm and its followers via Twitter affected by events external to the firm (that is, events that are not directly related to the firm)? In addressing this, we look at external shocks[1] that are related to the ICO realm (shocks about the cryptoassets world) and those that are unrelated to the firm (shocks related to other events) and explore how they influence the firm's decision to send tweets. (2) How is the reaction of the community of followers affected by the intensity of the ongoing conversation with the firm? This second point is very relevant because followers act as endorsers of the token issuer and may have an important effect on a firm's ability to gain legitimization (Jennings *et al.*, 2013; Suddaby *et al.*, 2016). All in all, we focus on how events external to the firm affect the Twitter activity of the firm and its investors.

Our analysis relies on weekly data about tweets issued by firms (in terms of the number of tweets containing different forms of messages from text to links, to videos) and the related reaction activity of the followers (retweets, likes, and replies). We also use data from Google trends about major external events (namely Brexit, Covid, and Trump administration activity) as well as the cryptoassets world (specifically Google trend data about ICOs, Bitcoin, and FinTech). Finally, we include in our analysis the tokens' returns, tokens' volatility, and tokens' volumes to control for the tokens' market performance because it may affect the intensity of the Twitter conversation. We use weekly data from 297 traded tokens for the period 2015–2020 (35,459 observations for the regressions). We regress (Poisson panel regression with canonical Poisson link function) token performance, Bitcoin, Morgan Stanley Capital International (MSCI), and Google trends against the tweets issued by the firm and the reactions of the community. We also retest our model by using lagged variables to check for possible reverse causality, and we employ additional controls and alternative econometric approaches.

We find that the Twitter activity of the firm is negatively associated with many external events (measured as their popularity in Google Trends), and this applies to all the topics except tweets that are very specific to the ICO world (i.e. tweets on ICOs or FinTech). Second, we find that the Twitter activity of the firm impacts the reaction of the community of followers. However, this relationship has an inverted U shape: the Twitter activity of the firm stimulates the reaction but at a decreasing speed, so that too many tweets reduce the reaction of the followers to the point that it turns negative. Our findings imply that: (1) firms are strategic in issuing tweets by avoiding tweeting when there are major events that distract followers; (2) the community of followers/investors acts as an amplifier of information dissemination, an aspect that is very important considering the endorsement role it plays; and (3) firms are careful in disseminating information because excessive tweets reduce the reaction activity.

Our study, by building on previous research on social media in alternative finance (Vismara, 2016), addresses the call for research on ICOs (Moro and Wang, 2020) by contributing to a better understanding of the dynamics behind the use of social media. Our evidence suggests that in the context of high information asymmetry (Jensen and Meckling, 1976) and where entrepreneurial opportunities are formed endogenously (Leyden *et al.*, 2014), the effective and efficient use of social media (Twitter) is a key success factor. We describe how the community of followers reacts and further disseminates the information issued by the firm. The endorsement that is implicit in 'reply', 'like', and 'retweet' activity may help to boost and reinforce the legitimization that highly innovative and technological firms need for their success. In fact, not only is legitimization important for future rounds of fundraising but it is also essential to establish a reputation that will facilitate the firm's relationship with other business partners. Intriguingly, even if our research grounds itself in ICO, the role of Twitter as an effective tool to communicate with investors may be extended to other types of investment that face asymmetry of information. All in all, our findings confirm the importance of the role of social media in information dissemination and legitimization.

Background and hypotheses development

ICO is a rather recent and innovative way to access finance. The process of ICO relies heavily on blockchain

[1]We would like to clarify that the term 'shock' is defined as major sudden event that is external and unrelated to the firm. Thus, there is no negative/positive connotation to our use of the word 'shock'.

technology, which is a specific type of distributed ledger, peer-to-peer and cryptographically secure technology that may replace any central processing authority (Narayanan *et al.*, 2016; Pilkington, 2015): the database is decentralized, and the storage of information is realized on a worldwide network of computers, called nodes, which communicate through the Internet. Thus (1) no one has control over all the information, and (2) data is not affected by the loss of one node (Nakamoto, 2008; Narayanan *et al.*, 2017). To communicate, the nodes use hash functions to enable security, precision, and the immutability of the data structure: when a new transaction is recorded, a new block is generated and added to the blockchain, validated by a distributed algorithm and communicated to all nodes to ensure a decentralized consensus in a peer-to-peer system. Thus, the system is resilient, and reliable, and allows for the management of any type of transaction from payments to contracts to issuing and transferring ownership of tokens, where tokens either represent ownership (security token) or grant access to some type of services delivered by the venture (utility token) (Adhami *et al.*, 2018; Lu, 2019; Chen, 2018; Narayanan *et al.*, 2017). Very recently, highly innovative start-ups that pursue IT-related projects started to use this technology to raise funds by issuing tokens via ICOs. The tokens can take different functions (Schückes and Gutmann, 2021): they can represent a share of the start-up and allow the investor to access a stream of future cash flows (security tokens); they can also represent the right to access the service the start-up aims to sell, or the right to obtain the service at a discount (utility tokens). Irrespective of the type of token, the ICO is typically associated with projects in their very early stages. After completion of the ICO, the tokens can be traded online (Roosenboom *et al.*, 2020).

Utility and security tokens are becoming quite popular tools to finance new, highly technological start-ups because they present interesting characteristics for both the investor and the venture. As far as the firm is concerned, issuing tokens can reduce the cost incurred in raising funds because this process is largely unregulated (Fisch, 2019; Howell *et al.*, 2020; Murphy, 2018): (1) issuers can cut costs linked to the traditional paperwork required by equity providers and there are no intermediaries to involve (Adhami *et al.*, 2018; Howell *et al.*, 2020); (2) the lack of regulation allows for greater flexibility, implying further cuts in costs (Fisch, 2019; Howell *et al.*, 2020; Huang *et al.*, 2020). Moreover, ICOs allow the firm to reach investors worldwide, without any geographical or legal barriers, which increases the ability of the venture to raise needed funds (Howell *et al.*, 2020; Huang *et al.*, 2020; Yermack, 2017).

As far as the investors are concerned, ICOs enable them to invest in new, highly innovative ventures, even when they are non-professionals, by allowing them to participate in the 'next Facebook'. More importantly, the minimum amount invested can be very small (like in crowdfunding), which makes it accessible to everyone. In addition, both security and utility tokens are digital cryptoassets that can be traded on a secondary market where transactions are managed by privately owned and largely unregulated platforms (Bellavitis *et al.*, 2021; Fisch and Momtaz, 2020). The simplified transferability – a major difference from equity crowdfunding or peer-to-peer lending (Lukkarinen *et al.*, 2016) – adds an interesting speculative motive for investors: the trading of tokens following an ICO. Hence, investors may decide to invest in ICOs with the expectation of substantial returns only on investment in the aftermarket.

ICO and Twitter

Recent research has tended to look at factors impacting ICO success in terms of the amount of funds raised, whether the issuer can reach the target amount, as well as the token market performance. For instance, Adhami *et al.* (2018) emphasize the positive impact of the availability of the code's source (GitHub), the organization of a token presale, the accessibility to specific services, and the specification of a jurisdiction. Later research explored the role of presale (Howell *et al.*, 2020), the existence of a hard cap during the presale (Amsden and Schweizer, 2018), the role of the white paper, that is, the document that illustrates the project (Adhami *et al.*, 2018; Amsden and Schweizer, 2018; Fisch, 2019), and the environmental dimension of the ICO (Mansouri and Momtaz, 2022). Compliance with the platform's regulation also seems to increase the chances of reaching the soft cap (Amsden and Schweizer, 2018; Fisch, 2019), while technical and financial information regarding a project is found to have a greater impact than other soft information (Moro and Wang, 2020). Finally, past research has also explored the characteristics of the leading team (Amsden and Schweizer, 2018; Colombo *et al.*, 2022; Howell *et al.*, 2020; Momtaz, 2021; Philippi *et al.*, 2021) and, in line with past research on start-ups (Bosma *et al.*, 2004), business experience is found to be relevant. There is also a growing body of literature on the ex-post success of ICOs (Amsden and Schweizer, 2018; Roosenboom *et al.*, 2020) suggesting that ICOs that disclose more information to investors and those that have a higher quality rating at the time of the campaign show stronger ex-post performance.

Past research very relevant to our work is that which focuses on the role of social media and that argues that social media affects people's opinions and behaviours (Fischer and Reuber, 2011). In the case of tokens, social media can address various aspects. First, it allows the firm to deal with the very high information asymmetry and the great level of uncertainty about the outcome that characterizes projects (Amsden and

Schweizer, 2018; Fisch, 2019; Perez *et al.*, 2020). Among different social media platforms, Twitter is the most widely used package to disseminate information (among Twitter, Telegram, and Reddit) thanks to its structure that allows for the spreading of information and avoids the ranking of the post (like in Reddit). Thus, tweets are considered the most helpful by token issuers to disseminate information about the venture, so that the investor community can access additional information beyond the formal information accessible on the website (Fisch, 2019; Momtaz, 2021). Second, by disseminating concise information (tweets are typically short), the firm can signal (Spence, 1973) its willingness to be transparent so that the investment can be perceived as having lower risk at a variance with situtations where there is the dissemination of large amounts of highly obscure and technical information (Pennycook *et al.*, 2015). Third, and partially because of the above-reported aspects, by appropriately managing information dissemination, the firm can increase its reputation/legitimization. Those offering ICOs have a strong interest in obtaining legitimization because on the one hand it can increase their success in future fundraising, and on the other it can help establish more solid relationships with business partners. All in all, firms are interested in issuing tweets that show their ability to 'conform' (adopt characteristics, forms and/or practices instituted by regulations, standards and norms within an organizational field), to 'decouple' (respond to social pressures by conforming so that they gain legitimacy in front of external audiences) and, particularly, to 'perform' (demonstrate the technical superiority of their innovative practice, characteristic or form over extant alternatives) (Suddaby and Greenwood, 2005; Suddaby *et al.*, 2016). The last strategy, based on the organization's ability to persuade key stakeholders (Elms and Phillips, 2009), is particularly relevant in the case of ICOs that try to 'sell' to the audience their technical superiority in exploiting blockchain technology. All in all, issuing tweets and communicating with the community of followers can enable the firm to successfully implement the 'performing strategy' by, at the same time, reassuring the community with the 'conform' and 'decoupling' strategies (Neilsen and Rao, 1987; Smith *et al.*, 2017; Suddaby and Greenwood, 2005; Suddaby *et al.*, 2016). Consequently, a firm's management has a strong incentive to increase Twitter activity when they have positive information to disseminate.

However, Twitter activity does not happen in a vacuum. External events (namely events not directly related to the firm) can also be a stimulus for the management to stay in contact with the followers. It is possible to differentiate between two types of external events: those that can have an impact on the firm because they are major events related to the context in which the firm operates; and those that are very important general events but only very marginally related to the firm and that are not expected to have any effect on its future performance. The former can be quite relevant for the issuer of the token because they can signal emerging trends or emerging issues that the token issuer can face. Thus, these events can stimulate Twitter activity because firms can be in a position where they must discuss, elaborate, or justify their choices so as to reassure the investors or explain strategies or changes in strategies. In other words, firms must show their 'conform' and 'decouple' as well as their 'perform' strategies (Suddaby *et al.*, 2016). Moreover, a proper reaction to these external events can reinforce the reputation of the firm and provide further transparency in dealing with the community of followers and investors. Finally, the traditional literature on entrepreneurship discusses whether entrepreneurial opportunities are created or discovered (Lehner and Kaniskas, 2012; Sarasvathy *et al.*, 2003), and some scholars suggest that they are formed endogenously by the entrepreneurs (Alvarez and Barney, 2007; Leyden *et al.*, 2014). If this is the case, entrepreneurs must support the 'perform' strategy further by disseminating information about the opportunity created by the start-up. Thus, we pose the following hypothesis:

H1: There is a significant positive relationship between Google searches on external events related to the firm's realm and the number of tweets issued by the firm.

ICO issuers that look for attention to maximize the social media use return (Shen *et al.*, 2015). However, any strategy implemented should consider that further dissemination via social media presents dynamics that are different from those of the epidemics (Feng *et al.*, 2015) because some constraints (e.g. Lotka–Volterra differential equations) do not apply. Research suggests that real-world social networks have a finite epidemic threshold in contrast to the zero thresholds in disease epidemic models (Feng *et al.*, 2015). This evidence suggests that when individuals are overloaded with excess information, the information may reach the population only if it is above the critical epidemic threshold: alternatively, it would never be well received. In other words, there is a saturation level, and beyond that the receiver does not pay attention to new tweets when they are not very relevant to them (above the threshold). Paying attention is a key step in the reaction: with no attention, there is no possible reaction (Da *et al.*, 2011). Major external events can have an impact on the saturation level even if they do not belong to the firm's realm. A major event that catches the attention of the followers may raise the critical threshold so that the followers will stop (at least temporarily) following the ICO. In such a context, there is no point in the firm issuing new tweets because the audience, distracted by the major event, may not pay sufficient attention to the firm's tweets (Feng *et al.*, 2015;

Goodier, 2018; Vergeer and Hermans, 2013). Thus, we argue that major events that do not relate to the firm are likely to reduce the firm's willingness to issue tweets and we hypothesize:

H2: There is a significant negative relationship between Google searches on external events not related to the firm's realm and the number of tweets issued by the firm.

Given their limited attention, investors are naturally selective in collecting and processing information (Da *et al.*, 2011; Huang *et al.*, 2019). Interestingly, initial social media activity to inform and build reputation can spark further activity from the community of followers that can be very important as it can trigger further endorsement (Courtney *et al.*, 2017), which, in turn, may help the venture to reinforce its reputation and gain legitimacy (Neilsen and Rao, 1987; Smith *et al.*, 2017; Suddaby and Greenwood, 2005; Suddaby *et al.*, 2016). Indeed, in the context of great information asymmetry, endorsements may be very important (Courtney *et al.*, 2017; Frydrych *et al.*, 2014).

Furthermore, 'likes' can be perceived as an endorsement by the investors' community (Courtney *et al.*, 2017) because they tend to suggest that those investors who are following the project 'endorse' the message and implicitly the project: if many members of the community are 'happy' with the information on the project/firm, it means there should be some quality in it. Moreover, retweets allow for broader dissemination of the message to those who do not belong to the inner circle of the current community. This implies an amplification in information dissemination linked to the retweet activity with a joint and implicit endorsement role. A similar logic applies to the 'reply' activity that signals interest in being involved in the conversation about the project. All in all, retweeting and replying activities imply that members of the community act as (1) disseminators of the information about the token and (2) endorsers (Courtney *et al.*, 2017). However, followers can also encounter Twitter fatigue: excess input (received tweets) can reduce the reaction for two reasons: first, they can demotivate people from reacting because they are overwhelmed by the number of tweets (Feng *et al.*, 2015); second, excess information can be interpreted negatively, as a way to hide important information below a large amount of potentially trivial information (Pennycook *et al.*, 2015). Thus, even if we expect a positive link with the Twitter activity of the firm and the reaction of the followers, we also hypothesize an inverse U-shaped relation: for a relatively low number of tweets issued by the firm, there is an increased reaction by the followers, but the pace at which followers engage in the conversation decreases with the increase in the number of issued tweets, and after a while the relation becomes negative. This argument takes us to the following hypotheses:

H3a: Given the audience's attention to firms' tweets, the audience's reaction (number of likes, replies, and retweets) is positively associated with the tweets' activity.

H3b: Given the audience's attention to firms' tweets, the audience's reaction (number of likes, replies, and retweets) is non-monotonic.

Moreover, by relying on the previous argument about the impact of external events on a firm's Twitter activity, we expect that major external shocks related to the cryptoassets' world tend to increase the reaction of the followers, while events that are unrelated to the ICOs' realm tend to distract the audience of the firm's followers from actively engaging in liking, retweeting or replying to the firm's tweets. Thus, we pose the following hypotheses:

H4a: Given the audience's attention to a firm's tweets, the audience's reaction (likes, replies, and retweets) is positively related to external shocks related to the firm's realm.

H4b: Given the audience's attention to a firm's tweets, the audience's reaction (likes, replies, and retweets) is negatively related to external shocks not related to the firm's realm.

Methodology, data and variable description

Data

This study focuses on tokens negotiated on HitBTC or Huboi platforms. We rely on these platforms because they are old enough to provide market data for at least 2 years and they jointly cover a good number of tokens. We use weekly data about ICO traded for at least 104 weeks (~2 years) by the end of the data collection (Monday 3rd August 2020).

All public tweets were gathered until 3rd August 2020, with the following information: date, type of content, number of replies, retweets, 'likes', and list of the media present in each tweet (quote, link, image, video, and GIF).

The number of observations used, even if relatively small (297 tokens for overall 35,459 observations entered in the regressions), is in line with past studies that look at tokens (Benedetti and Kostovetsky, 2021; Fisch, 2019; Fisch and Momtaz, 2020; Momtaz, 2021).

Methodology

Our dependent variables measure the number of tweets (H1 and H2) and the number of retweets (H3 and H4) issued respectively by firms and by followers so that they can be interpreted as the frequency of the dissemination of new tweets in the community. They resemble a Poisson random process: we are interested in the number of events (new tweets) per unit of time (Dunteman and Moon-Ho, 2006). Thus, we model our regressions using panel Poisson regression, where the dependent variable is a random variable that follows a Poisson process with canonical link function. Because there are some extreme observations, we winsorize the number of tweets as well as the retweets at the 5th and 95th percentiles. Moreover, the market data of the tokens (returns, volumes, volatility) are skewed. To reduce their skewness, we take the log of these variables. In fact, because the return on tokens can have both positive and negative values, we first 'move the values to the right' (so that all the values are positive) and then we take the log of the translated return.

We employ a robust estimation of the standard errors. Moreover, we retest our model by using pooled Poisson regression, random effect, fixed effect, and population average Poisson panel regression to obtain results that are robust to different estimation approaches. Because the standard deviation of our observations is marginally bigger than the average (the observations do not perfectly fit a Poisson process), we also retest our model using a Negative Binomial panel data model (fixed effects, random effects, population average and robust estimation of the standard errors). Finally, we also use lagged values for Google trends to check for possible reverse causality. We employ three models:

$$Tweets_{i,t} = c + \alpha_1\delta_t + \alpha_2\zeta_t + \alpha_3\theta_{i,t} + \alpha_4\kappa_t + \varepsilon_1, \quad (1)$$

where δ_t is a vector of Google trends at time t and has coefficients related to words associated with the cryptoasset realm, aimed at exploring the popularity of major events in the FinTech, RegTech, and Cryptoassets world on tweeting activity; ζ_t is a vector of Google trend coefficients at time t related to words associated with some major 'external' events that are not related to the cryptoassets world. Among the major events of 2015–2020, we limit our exploration to Brexit (the major political/economic event in Europe with effects on the rest of the world), Covid (a worldwide major event during 2020), and the Trump effect (to catch the impact of the variability of US policies). In addition, $\theta_{i,t}$ is a vector of variables relative to the market performance of firm i at time t. Finally, κ_t represents a vector of controls at time t. Moreover, we estimate a second model:

$$ReTweets_{i,t} = c + \beta_1\delta_t + \beta_2\zeta_t + \beta_3\theta_{i,t} + \beta_4\kappa_t + \beta_5 Tweets_{i,t} + \varepsilon_2, \quad (2)$$

where $Tweets_{i,t}$ is a vector representing the tweets issued by firm i at time t, and δ_t, ζ_t, $\theta_{i,t}$ and κ_t have the same meaning as in (1).

Finally, we check for non-linearity (non-monotonicity) by estimating the following model:

$$ReTweets_{i,t} = c + \gamma_1\delta_t + \gamma_2\zeta_t + \gamma_3\theta_{i,t} + \gamma_4\kappa_t + \gamma_5 Tweets_{i,t} + \gamma_6 Tweets^2_{i,t} + \varepsilon_2, \quad (3)$$

where $Tweets^2_{i,t}$ is a vector representing the square of tweets issued by firm i at time t, and δ_t, ζ_t, $\theta_{i,t}$, κ_t and $Tweets_{i,t}$ have the same meaning as in (2).

Descriptive

The list of variables and their descriptions are reported in Table 1, while a summary of the statistics is reported in Tables 2 and 3. We also provide graphs of the empirical (the observed distribution, in green) and the theoretical (the theoretical Poisson distribution with the same lambda, in white) distribution of tweets in Figure 1A and B.

The number of tweets issued by firms is between 0 and 89, with an average of 4.28 and a standard deviation of 4.79. The data suggest a rather skewed distribution that can be modelled using a Poisson process (mean and standard deviation are almost identical). The number of reactions is larger (between 0 and 6275), with an average of 390 and a standard deviation of 687. In this case, the Poisson process does not necessarily fit the data well. Some doubts about whether the Poisson process suitably models the dependent variable are also raised in Figure 1A and, more importantly, in Figure 1B. This is the primary reason behind re-estimating the model by also using the Negative Binomial regression.

All the Google trend indices have a maximum value of 100 (Google trend indexes the popularity of a theme in terms of searches during the given time window between 0 and 100). The variable related to Covid started from zero (there were no searches during the first year in our time window).

The correlation table suggests a somewhat marginal correlation among the Google trend indices. Only ICO and FinTech, Covid and ICO, Covid and Brexit, and Covid and FinTech present correlations above 0.50, with a very strong correlation between Covid and ICO (0.8670) linked to the fact that the two themes gained momentum in the same part of the time window considered.

Results

Table 4 reports the results of Twitter activity as a 'disseminator' of information to a community of followers. Table 4, model 1A considers only major events that are external to the firm issuing a token.

The results suggest no significant effect exerted by the MSCI world index and a negative significant effect

Table 1. Variables

	Variables	Description
Dependent variables	Number of tweets	Winsorized number of tweets issued by the firm
	Number of reactions	Winsorized number of retweets issued by the investors
Independent variables	Natural logarithm of the ROI (+100%)	Winsorized natural logarithm of the ROI of the token issues via ICO
	Natural logarithm of Volumes	Winsorized natural logarithm of the volumes of the token issued via ICO
	Natural logarithm of Volatility	Winsorized natural logarithm of the standard deviation of the token issued via ICO
	MSCI world index	MSCI world index
	BTC weekly performance	Bitcoin's weekly change in value
	Google Trend FinTech	Google trend coefficient for searches involving the word 'FinTech'
	Google Trend Bitcoin	Google trend coefficient for searches involving the word 'Bitcoin'
	Google Trend ICO	Google trend coefficient for searches involving the word 'ICO'
	Google Trend Covid	Google trend coefficient for searches involving the word 'Covid'
	Google Trend Brexit	Google trend coefficient for searches involving the word 'Brexit'
	Google Trend Trump	Google trend coefficient for searches involving the word 'Trump'
	First Covid death in EU	Dummy variable (0 before the first death in EU; 1 otherwise)
	First Covid death in the US	Dummy variable (0 before the first death in US; 1 otherwise)
	EU enters lockdown	Dummy variable (0 before the EU enters lockdown; 1 otherwise)
	EU takes over China for deaths count	Dummy variable (0 before EU has fewer deaths than China; 1 after)

exerted by Bitcoin (BTC) performance: the performance of BTC attracts attention and implicitly reduces the interest of the firm in disseminating information in a context where their information might not be properly received by the community of followers. Unexpectedly, the same applies to Google trends linked to Fintech and Bitcoin: possibly because these themes (which are quite general) can distract the audience from the ICO, firms tend to reduce their tweets when these themes grow in popularity. Regression 1A only partially supports H1. All the external events that are not related to ICOs (i.e. Brexit, US administration policies, Covid) are significantly and negatively related to the tweeting activity of the firm issuing a token (as expected according to H2). External events are a 'distraction' for the community, so it is better for the firm to reduce Twitter activity because any new message they want to disseminate may not be read/circulated by the community, which is more focused on/interested in other events.

Model 2A includes tokens' market performance as an additional control. Interestingly, the added variables are not significant except for the volumes (positively related to the number of tweets). However, we are inclined to interpret this more as an association than causation. When adding these controls nothing changes as far as the core variables are concerned, except for MSCI, which is now significant at 5%. Model 3A also considers the lagged variable of the number of issued tweets (and of the market performance of the tokens) so that we can explore whether there is a lagged effect. Among the added variables only the lagged volume is significant, while there are no major changes among other variables.

All in all, our results provide marginal support to H1 (there is a significant positive relationship between the external events related to the firm's realm and the number of tweets issued by the firm) and they provide strong support to H2 (there is a significant inverse relationship between the external events not related to the firm's realm and the number of the tweets issued by the firm).

The results in Table 5 highlight the 'endorsement role' of retweeting activity, moving away from the pure dissemination and legitimization role.

Model 1B considers all the external factors and the number of tweets issued by the firm as determinants of retweeting activity (reaction of the community of followers). Interestingly, the reaction is positively and significantly affected by the tweeting activity of the firm: the more the firm tweets, the greater the reaction in terms of likes, retweets, and replies from the community of followers. The results do not change when we

Table 2. Descriptive statistics of the variables

Variables	Obs	Mean	Std Dev.	Min	Max
Number of tweets	38,037	4.2844	4.7951	0	89
Number of reactions	38,037	390.6392	687.3994	0	6275
Natural logarithm of the ROI (+100%)	38,037	–0.0184	0.2024	–3.5066	2.7024
Natural logarithm of Volumes	37,879	–2.6282	3.7051	–19.0677	7.2793
Natural logarithm of Volatility	37,739	–2.9295	0.8130	–12.5599	3.0410
MSCI world index	36,134	0.0011	0.0301	–0.1245	0.1098
BTC weekly performance	36,980	0.0083	0.1074	–0.3722	0.4320
Google Trend FinTech	38,037	54.7688	12.0638	4	100
Google Trend Bitcoin	38,037	12.9863	9.4567	1	100
Google Trend ICO	38,037	14.0854	15.0906	1	100
Google Trend Covid	38,037	11.5171	25.7137	0	100
Google Trend Brexit	38,037	3.9253	3.8126	0	100
Google Trend Trump	38,037	7.6813	2.5453	2	100
First Covid death in EU	38,037	0.0078	0.0880	0	1
First Covid death in the US	38,037	0.0078	0.0880	0	1
EU enters lockdown	38,037	0.0078	0.0880	0	1
EU takes over China for deaths count	38,037	0.0078	0.0880	0	1

Variables: Number of Tweets, Number of Reactions, Natural logarithm of Return; Natural logarithm of Volumes, Natural logarithm of Volatility; MSCI world index, BTC weekly performance, Google Trend about FinTech, Google Trend about Bitcoin, Google Trend about ICO, Google Trend about Covid, Google Trend about Brexit, Google Trend about Trump, Dummy Variable First Covid Death in EU, Dummy Variable First Covid Death in the United States, Dummy Variable EU Enters Lockdown, Dummy Variable EU takes over China for Deaths count.

also account for the performance of the token (models 2B–5B), or the lagged performance of the token (models 3B and 5B), or when we explore the non-monotonicity of the relationship between tweets and retweets (models 4B and 5B). Furthermore, the inclusion of the lagged number of tweets issued by the firm (models 3B and 5B) suggests that any activity performed by the firm is very rapidly 'absorbed' by the community so that its effect dissipates in less than one week (the lagged variable is not significant). Of particular interest is the result obtained in regressions 4B and 5B, which explore the monotonicity of the relationship between tweets issued by the firm and the retweeting activity. The square of the tweets is significantly but negatively related to the tweeting activity, suggesting that the tweeting activity of the firm loses momentum in stimulating the reaction of followers to the point that it becomes negative. The finding is in line with H3b stating that the audience's reaction to tweets (likes, replies, and retweets) is non-monotonic to the number of tweets issued by the firm. Moreover, the regressions presented in Table 5 provide consistent support to H3a: the audience's reaction to tweets (likes, replies, and retweets) is positively associated with the firm's tweeting activity.

Table 5 regressions also allow for the exploration of the role of external factors: first, the reaction in terms of tweets is not affected in any way by the performance of the traditional financial markets (MSCI index) or by the performance of the most popular cryptoasset (BTC); second, the popularity of the narrative around ICO and BTC positively and significantly affects the retweeting activity: when there is an increased interest in cryptoassets, the community is more prone to expanding the conversation around the tweets issued by the firm (likes, retweets, replies). However, this does not apply to the general discussion about FinTech, possibly because it is quite a niche topic that is partially related to the ICO world. The results are broadly in line with our H4a. The popularity of major topics that are not related to ICOs is significantly and negatively related to the retweeting activity of the community of followers because these topics 'distract' the audience by moving the focus of the followers from the tokens to other major topics. Consequently, results are in line with our H4b: the audience's reaction to tweets (likes, replies, and retweets) is negatively related to external shocks not related to the firm's realm.

Robustness checks

The evidence presented so far shows consistency. However, some criticisms can be raised. First, our basic regressions are estimated using random effects and robust estimation of the standard errors. It can be argued that alternative approaches such as pooled Poisson regression or panel Poisson with fixed effects or panel Poisson with population average could produce different results. These differences could be due, in the case of the pooled Poisson, to the assumptions regarding the α_i (α_i is independent of x_i with mean 0); in the case of Poisson with fixed effects, α_i is potentially correlated with x_i; for Poisson with population average, we assume equicorrelation. We retested our Poisson with random effects model using different assumptions and obtained results that are consistent with the original ones.

Table 3. Correlation table of the variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of tweets	1.0000															
Number of reactions	0.5235	1.0000														
Natural logarithm of the ROI (+100%)	0.0050	0.0187	1.0000													
Natural logarithm of Volumes	0.2108	0.3744	0.0211	1.0000												
Natural logarithm of Volatility	–0.0494	–0.0796	0.1227	–0.1534	1.0000											
MSCI world index	–0.0087	–0.0064	0.0547	–0.0125	–0.0642	1.0000										
BTC weekly performance	–0.0233	–0.0194	0.0262	–0.0168	–0.0273	0.0597	1.0000									
Google Trend FinTech	–0.0747	–0.1104	0.0502	–0.0977	–0.0588	0.1531	0.0380	1.0000								
Google Trend Bitcoin	–0.0090	0.1039	–0.0906	0.1057	0.1265	–0.1187	–0.0314	–0.1190	1.0000							
Google Trend ICO	0.0061	0.0601	0.0097	0.0355	0.0003	0.1537	0.0117	–0.1716	0.4345	1.0000						
Google Trend Covid	–0.0840	–0.0721	0.0457	–0.1013	–0.0604	0.0195	0.0849	–0.0347	0.2860	0.5933	1.0000					
Google Trend Brexit	–0.0241	–0.0663	0.0493	–0.0674	–0.0401	0.0436	0.0185	0.1429	–0.3401	–0.3001	–0.3644	1.0000				
Google Trend Trump	–0.0564	–0.0455	0.0567	–0.0779	–0.0699	0.0174	–0.0997	–0.0783	0.1300	0.2305	0.5182	–0.2587	1.0000			
First Covid death in EU	–0.0118	–0.0175	0.0017	–0.0014	0.0360	0.0304	–0.0235	0.0201	0.0033	–0.0459	–0.0386	–0.0484	–0.0238	1.0000		
First Covid death in the US	–0.0172	–0.0207	0.0062	–0.0109	–0.0090	–0.0391	–0.0049	0.1273	0.0032	–0.0396	–0.0280	–0.0483	0.0138	–0.0083	1.0000	
EU enters lockdown	–0.0179	–0.0191	–0.0036	–0.0272	0.0043	–0.3698	0.2619	–0.1010	0.1085	0.1263	0.3006	–0.0709	0.1616	–0.0082	–0.0081	1.0000
EU takes over China for deaths count	–0.0165	–0.0229	–0.0300	–0.0194	0.0507	–0.3814	–0.3357	–0.1947	0.2173	0.0598	0.2289	-0.0721	0.2017	-0.0083	-0.0083	-0.0081

Variables: Number of Tweets, Number of Reactions, Natural logarithm of Return; Natural logarithm of Volumes, Natural logarithm of Volatility; MSCI world index, BTC weekly performance, Google Trend about FinTech, Google Trend about Bitcoin, Google Trend about ICO, Google Trend about Covid, Google Trend about Brexit, Google Trend about Trump, Dummy Variable First Covid Death in EU, Dummy Variable First Covid Death in the United States, Dummy Variable EU Enters Lockdown, Dummy Variable EU takes over China for Deaths count.

Table 4. Poisson regression: tweets issued by the firm

Variables	**(1) Model 1A**	**(2) Model 2A**	**(3) Model 3A**
MSCI world index	–0.1567	–0.2134*	–0.1816
	(0.1196)	(0.1233)	(0.1217)
BTC weekly performance	–0.1601***	–0.1498***	–0.1207***
	(0.0408)	(0.0406)	(0.0405)
Google Trend FinTech	–0.0048***	–0.0035***	–0.0032***
	(0.0008)	(0.0007)	(0.0007)
Google Trend Bitcoin	–0.0082***	–0.0137***	–0.0143***
	(0.0020)	(0.0023)	(0.0023)
Google Trend ICO	0.0053***	0.0040***	0.0039***
	(0.0009)	(0.0008)	(0.0008)
Google Trend Covid	–0.0056***	–0.0039***	–0.0038***
	(0.0010)	(0.0009)	(0.0009)
Google Trend Brexit	–0.0149***	–0.0095***	–0.0091***
	(0.0024)	(0.0022)	(0.0022)
Google Trend Trump	–0.0112***	–0.0074***	–0.0072***
	(0.0025)	(0.0025)	(0.0026)
First Covid death in EU	–0.1837***	–0.1798***	–0.1679***
	(0.0483)	(0.0490)	(0.0492)
First Covid death in the US	–0.1829***	–0.1693***	–0.1843***
	(0.0475)	(0.0475)	(0.0499)
EU enters lockdown	0.1356**	0.1338**	0.1209**
	(0.0628)	(0.0604)	(0.0611)
EU takes over China for the number of deaths	0.0135	0.0451	0.0611
	(0.0617)	(0.0599)	(0.0608)
Natural logarithm of the ROI (+100%)		–0.0191	0.0075
		(0.0241)	(0.0241)
Natural logarithm of Volumes		0.0686***	0.0427***
		(0.0092)	(0.0056)
Natural logarithm of Volatility		0.0026	0.0106
		(0.0138)	(0.0114)
Natural logarithm of the ROI (+100%) = L,			0.0362
			(0.0262)
Natural logarithm of Volumes = L,			0.0306***
			(0.0054)
Natural logarithm of Volatility = L,			–0.0025
			(0.0111)
Constant nbtweet_w	1.9418***	2.0404***	2.0579***
	(0.0592)	(0.0754)	(0.0896)
/lnalpha	–0.3567	–0.3919	–0.3677
	(10.1280)	(10.3131)	(10.3754)
Observations	36,134	35,844	35,459
Number of idkey	297	297	297
Chi-squared	1835	1980	1991
p	0.0000	0.0000	0.0000

This table reports results of the Equation (1) focusing on the tweets. A detailed definition of the variables is provided in Table 1. The time under investigation considers ICO traded for at least 104 weeks (from 24 August 2015 until 3 August 2020). Robust standard errors are in parenthesis. * sig. at 0.10; ** sig. at 0.05; *** sig. at 0.01.

Second, as discussed in the methodology section, differences between average and standard deviation can raise doubts about the use of a Poisson process for modelling the behaviour of the arrival of new tweets. Thus, we explored the behaviour of the dependent variable using an alternative random model, namely a negative binomial. We performed these robustness tests on models from Table 4 and from Table 5 that have the lowest value of the Bayes Information Criteria (the models that could be said to be the best performers). The results are reported in the Appendix (Tables A1 and A2) and are qualitatively identical to our main results.

Third, we cannot rule out a possible reverse causality between Google activity and tweets: firms (and investors) could react to the popularity of ICO-related topics (increase in Google trends) by tweeting more. To test for the possible reverse causality, we re-estimated the model using 1- and 2-week lags of Google trends (regressions not reported for the reason of space). Nothing changes in the results: the lagged variables

Table 5. Poisson regression: re-tweets (reactions to tweets issued by the firm)

Variables	**1** **Model 1B**	**2** **Model 2B**	**3** **Model 3B**	**4** **Model 4B**	**5** **Model 5B**
Number of tweets during the week	0.1156***	0.1097***	0.1073***	0.3380***	0.3365***
	(0.0055)	(0.0053)	(0.0047)	(0.0118)	(0.0117)
Number of tweets during the week = L,			0.0042		0.0022
			(0.0028)		(0.0023)
Square of the number of tweets				–0.0115***	–0.0115***
				(0.0005)	(0.0006)
MSCI world index	–0.2481	–0.2821	–0.3496*	0.0597	–0.0126
	(0.1795)	(0.1846)	(0.1827)	(0.1717)	(0.1688)
BTC weekly performance	–0.0521	–0.0897*	–0.0627	–0.0756	–0.0586
	(0.0520)	(0.0535)	(0.0538)	(0.0496)	(0.0500)
Google Trend FinTech	–0.0113***	–0.0103***	–0.0100***	–0.0099***	–0.0096***
	(0.0009)	(0.0010)	(0.0010)	(0.0007)	(0.0007)
Google Trend Bitcoin	0.0170***	0.0080***	0.0067***	0.0069***	0.0057***
	(0.0017)	(0.0021)	(0.0022)	(0.0018)	(0.0019)
Google Trend ICO	0.0074***	0.0066***	0.0061***	0.0071***	0.0067***
	(0.0012)	(0.0012)	(0.0012)	(0.0010)	(0.0010)
Google Trend Covid	–0.0087***	–0.0075***	–0.0071***	–0.0083***	–0.0080***
	(0.0011)	(0.0010)	(0.0010)	(0.0009)	(0.0009)
Google Trend Brexit	–0.0227***	–0.0161***	–0.0154***	–0.0216***	–0.0211***
	(0.0032)	(0.0030)	(0.0030)	(0.0026)	(0.0026)
Google Trend Trump	–0.0079***	–0.0026	–0.0032	0.0031	0.0025
	(0.0027)	(0.0029)	(0.0029)	(0.0027)	(0.0027)
First Covid death in EU	–0.4259***	–0.4944***	–0.4908***	–0.4977***	–0.5029***
	(0.0563)	(0.0578)	(0.0582)	(0.0511)	(0.0522)
First Covid death in the US	–0.3105***	–0.3150***	–0.3553***	–0.3585***	–0.3976***
	(0.0587)	(0.0594)	(0.0590)	(0.0574)	(0.0577)
EU enters lockdown	–0.0270	–0.0238	–0.0834	0.0132	–0.0360
	(0.0875)	(0.0909)	(0.0930)	(0.0832)	(0.0850)
EU takes over China for the number of deaths	–0.5620***	–0.5875***	–0.5673***	–0.5094***	–0.4900***
	(0.0906)	(0.0956)	(0.0972)	(0.0831)	(0.0848)
Natural logarithm of the ROI (+100%)		0.0072	0.0544	–0.0121	0.0258
		(0.0409)	(0.0424)	(0.0330)	(0.0326)
Natural logarithm of the ROI (+100%) = L,			0.0775**		0.0965***
			(0.0345)		(0.0337)
Natural logarithm of Volumes		0.0820***	0.0551***	0.0708***	0.0495***
		(0.0160)	(0.0124)	(0.0135)	(0.0099)
Natural logarithm of Volumes = L,			0.0286***		0.0226***
			(0.0086)		(0.0077)
Natural logarithm of Volatility		0.0901***	0.0810***	0.0873***	0.0776***
		(0.0161)	(0.0137)	(0.0136)	(0.0115)
Natural logarithm of Volatility = L,			0.0558***		0.0551***
			(0.0123)		(0.0112)
Constant nbtweet_w	5.7182***	6.1043***	6.2409***	5.3518***	5.4881***
	(0.1081)	(0.1278)	(0.1423)	(0.1117)	(0.1240)
/lnalpha	0.3347	0.2464	0.2798	0.1671	0.2024
	(7.6616)	(8.0356)	(8.0789)	(7.8303)	(7.8925)
Observations	36,134	35,844	35,459	35,844	35,459
Number of idkey	297	297	297	297	297
chi-squared	12392	14323	15144	18623	21564
p	0..0000	0.0000	0.0000	0.0000	0.0000

This table reports results of the Equations (2) and (3), focusing on the re-tweets. A detailed definition of the variables is provided in Table 1. The time under investigation considers ICO traded for at least 104 weeks (from 24 August 2015 until 3 August 2020).
Robust standard errors in parenthesis. * sig. at 0.10; ** sig. at 0.05; *** sig. at 0.01.

are significant but, more importantly, they retain the same sign, suggesting that we do not face any reverse causality.

Fourth, even if Twitter's ban of 26th March 2018 on ICO advertisements is not related to the type of tweets we explore, we cannot completely rule out a possible impact. Thus, we performed an additional robustness check by including a dummy that has a value of 0 before the ban and 1 after the ban (results not reported owing to space limitations). The additional dummy

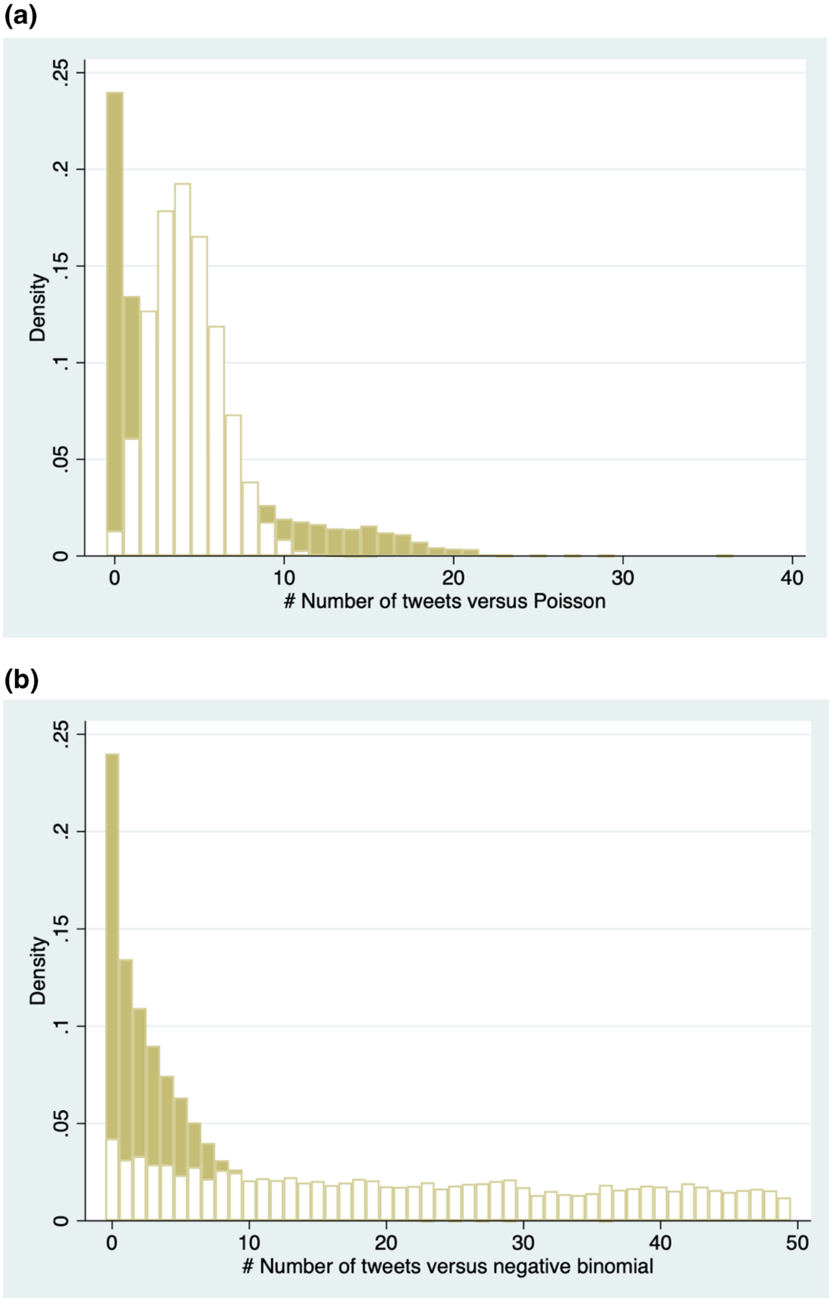

Figure 1. Tweets A, B [Colour figure can be viewed at wileyonlinelibrary.com]

variable is not significant. More importantly, there are no changes in the sign and significance of the other variables. In addition, we checked for potential omitted variable issues by re-estimating the regressions with dummies that identify whether the ICO also uses alternative social platforms (namely, Facebook, Telegram, Reddit, and LinkedIn) (regressions not reported for reasons of space). The inclusion does not affect our results. Interestingly, the platform dummies are not significant in the case of tweeting but they are significant in the case of retweeting.

Finally, one cannot rule out that there could be a substitution effect between Google searches and the tweeting activity: if there are many Google searches, investors may already have the information they need, and thus there is no need for the ICO issuer to deliver additional information. In fact, we include Google searches that are related to general topics (e.g. ICOs), while Twitter activity is mainly about the specific ICO so the substitution effect is quite unlikely. However, to check for this possibility we retested our models using the square of the Google searches about ICO. Intriguingly, the additional variable turns out to be significant but with an inverted sign, suggesting non-monotonicity (and a possible substitution effect). However, we suggest prudence in deriving a substitution effect from our result. This topic needs further investigation based on the content of tweets, which would allow for a discrimination between more general information (that can be substituted by Google searches) and very specific information.

Discussion

ICOs are characterized by very high information asymmetry (Jensen and Meckling, 1976) because of the lack of regulation, lack of history of the issuers, and the innovativeness of the project pursued, meaning that the asymmetry faced is greater than that faced by investors in more traditional start-ups. In such a context, Twitter can act as a 'disseminator' of information about the project and as a 'legitimizer' (Suddaby and Greenwood, 2005; Suddaby *et al.*, 2016). However, when Twitter activity moves to retweeting, replying to and liking original tweets, it moves away from the pure dissemination and legitimization role and takes the 'endorsement role' (Bodaghi and Oliveira, 2020; Gruber, 2017; Saluzzo and Alegre, 2021). At this stage, the behaviour of the community of followers can affect the behaviour of current and potential investors (Fischer and Reuber, 2011, 2014).

Our research suggests that highly innovative and informationally asymmetric firms issuing tokens are aware of the important role played by Twitter. They rely on tweets to keep the community informed, but they are also quite careful in managing this tool: they reduce its use when the community is 'busy' discussing major external events. At the same time, when there is greater interest in the realm of the cryptoassets and, more importantly, there are no major external events that distract the audience, firms increase the issuing of tweets. Furthermore, members of the community are quite happy to engage in a conversation with the firm and, more importantly, with a wider community of followers and non-followers, as supported by their reactions to the issuing of tweets. By liking the message, the members of the community are implicitly endorsing the message (there is no point in liking a message with which one disagrees). However, if the liking activity were to remain inside the community of followers, it would have a marginal effect, particularly if the community's members were already investors in the venture. When the 'liking' activity is associated with retweeting and replying, there are two additional effects: (1) the project receives the endorsement of the followers; (2) the number of individuals who receive the message expands beyond the original community. All in all, endorsement has an important effect because it may stimulate the investment decision of new investors. This result is in line with past research that finds that social media: (1) helps in gaining reputation, legitimacy and endorsement (Smith *et al.*, 2017; Courtney *et al.*, 2017); (2) plays a key role in innovative forms of finance (Vismara, 2016); and (3) increases the likelihood of success in raising funds (Frydrych *et al.*, 2014). However, our results suggest that this approach works with one important caveat: the firm has to not issue too many tweets (non-monotonicity of the relation between issued tweets and reaction). Excessive Twitter activity by the firm can generate confusion among the community members. The community can: (1) struggle to discriminate what is relevant from what is trivial; (2) perceive excess communication as an attempt to avoid engaging in a proper conversation and being transparent with the audience (Pennycook *et al.*, 2015).

Conclusion

By considering tokens and exploring the determinants of Twitter activity, this study expands the existing literature on the role of social media as a tool to reduce information asymmetry between investors and investees (Vismara, 2016). So far, research has looked at Twitter as a possible determinant of the success of ICOs and token market performance. No past research has explored what affects the tweeting decisions and, more importantly, the intensity of the reaction of the community of followers. Therefore, this study fills a gap in the literature by adding new and interesting findings beyond the pure ICO realm.

We looked at Twitter (the most popular platform by the number of users) as an information disseminator, a legitimizer, and an endorser. We found that firms are effective in managing the issuing of tweets by avoiding issuing them in periods when other major themes have momentum, when followers can be distracted and pay no attention to the tweets and the information contained in them. Intriguingly, only an increase in the popularity of topics very close to the ICO (Google trend on ICO) stimulates the intensity of the Twitter activity performed by the firm. All other types of events, both related and unrelated to the ICO realm, are negatively related to the Twitter activity of the firm. Moreover, we found that the intensity of the reaction, which acts as a further legitimization of the firm via the endorsement of the community of followers, is non-monotonically related to the intensity of the tweets issued by the firm. This implies that firms should carefully manage the conversation with the community of followers and should try to avoid feeding them with too many tweets.

Our results expand on very recent work on ICOs (Fisch, 2019; Fisch *et al.*, 2021; Howell *et al.*, 2020; Benedetti and Kostovetsky, 2021) as well as on research on the use of social media in alternative forms of finance (Vismara, 2016) discussing its role as legitimizer and endorser. Our evidence suggests that research must be more careful in treating Twitter (and social media) as a general class, consequently limiting its role as an information disseminator. Social media activity cannot be considered a homogeneous class (e.g. Twitter activity, Facebook followers, etc.) because different activities can be associated with different 'meanings'. Thus, even if our main contribution is in showing the role of Twitter as an endorser/legitimizer, we also contribute to future research by highlighting the importance of looking at social media in a more fine-grained way, trying to disentangle the different roles it can have. Besides, even if our findings are based on ICOs, they can be generalized to all the small, innovative firms that are characterized by high levels of information asymmetry. Moreover, they can also potentially be extended to the IPO context (given some similarities between ICOs and IPOs), suggesting that further research related to Twitter in the IPO context could be very beneficial.

However, there are limitations to this study that open avenues for further research. The dataset used is quite small, mostly owing to the ICO phenomenon being very recent. Further research on larger datasets could explore whether our suggestive results are confirmed. One additional, technical, limitation is linked to Twitter statistics: it might be possible that Twitter accounts are subject to tweet deletion, so that the number of tweets by type is not necessarily the original one. It is not possible to know whether this occurred. However, we tend to think that the amount of information lost should be quite limited and is expected to not affect the results we obtained. Moreover, because information can be disseminated using alternative social media platforms, future research could explore the role of alternative platforms. Additionally, our research does not include information about the leading team of the firm (e.g. age, education, work experience). However, we cannot rule out that strength of leading a team (and, thus, the need to gain legitimization in the investor/business community) as well as the team's familiarity with social media could have a significant role in the way Twitter is used. Finally, we looked at the Twitter intensity, not at the content of the tweets. This is an important limitation because research has suggested that there is a tendency to embellish information (Momtaz, 2020) and that the content can be relevant in the decision process (Mansouri and Momtaz, 2022). Furthermore, this limitation does not allow us to make a final statement about the non-monotonicity of Google searches. Future works could expand the research further by exploring tweet content in terms of information disseminated and specific comments/reactions by the community and explore the role of information embellishment. Besides, content analysis may also allow us to identify those tweets that substitute for Google searches (and thus the non-monotonicity of Google searches) as well as to explore the role of tweets to inform the community versus tweets that have an advertising role.

We focus on Twitter because, currently, this is the most popular social media in the realm. Needless to say, it would be interesting to explore whether the evidence we found applies to other social media tools (e.g. Facebook, Reddit, Telegram, etc.).

Notwithstanding its limitation, this research, by providing a more detailed and fine-grained picture of the role of Twitter activity, offers additional insight into how a very innovative way of financing high-technology start-ups may be influenced by social media (Twitter), pointing to the very important role (disseminating, endorsing and legitimizing) that social media could have in business and financing relationships.

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Supporting Information

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