Theories of crowdfunding and token issues: a review

Miglo, Anton

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Anton Miglo

University of Glasgow

anton.miglo@glasgow.ac.uk

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Abstract

Entrepreneurial, innovative and small- and medium-sized firms experience difficulties with raising funds using traditional debt and equity. Consequently, they are constantly looking for new strategies of financing. Latest inventions are crowdfunding and token issues. In contrast to traditional ways of raising funds these innovations: 1) use modern technology (on-line transactions, blockchain etc.) much more actively; 2) are usually quicker in reaching potential investors/funders; 3) use more actively network benefits such as, for example, a large number of interactions between investors/funders and between funders and firms. These changes are so significant that some experts list them among the top business inventions of 21st century. This article provides a review of the growing number of theoretical papers in the areas of crowdfunding and token issues, compare their findings with empirical evidence and discuss directions for future research. The research shows that a large gap exists between theoretical literature and empirical literature.

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JEL Codes: F30, G15, G18, G21, G24, G28, G32, G38, M13

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Abstract

Entrepreneurial, innovative and small- and medium-sized firms experience difficulties with raising funds using traditional debt and equity. Consequently, they are constantly looking for new strategies of financing. Latest inventions are crowdfunding and token issues. In contrast to traditional ways of raising funds these innovations: 1) use modern technology (on-line transactions, blockchain etc.) much more actively; 2) are usually quicker in reaching potential investors/funders; 3) use more actively network benefits such as, for example, a large number of interactions between investors/funders and between funders and firms. These changes are so significant that some experts list them among the top business inventions of 21st century. This article provides a review of the growing number of theoretical papers in the areas of crowdfunding and token issues, compare their findings with empirical evidence and discuss directions for future research. The research shows that a large gap exists between theoretical literature and empirical literature.

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1. Introduction

Financing is crucial for entrepreneurial firms, innovative firms as well as for small- and medium-sized businesses (see, for example, Hall (2009), Wilson (2015), Nicolo (2015), Capizzi and Carluccio (2016), Ceptureanu, Ceptureanu and Sassu (2017)). Crowdfunding in its modern form (performed online) and token issues are the latest topics in this area. Crowdfunding is sometimes ranked/credited as one of leading business/technology innovations of recent years.[2] As will be shown in this review many theoretical ideas behind crowdfunding and token issues are quite similar. For example an idea of raising funds for new products development and getting future customers at the same time.[3] In this review we will discuss these commonalities as well as the differences between these new phenomena.

[2] See e.g. http://www2.technologyreview.com/tr10/?year=2012
[3] This applies to reward-based crowdfunding and utility token issues.

Crowdfunding and token issues are highly growing areas of interest among practitioners and theorists (see eg Ahlstrom, Cumming and Vismara (2018), Masiak et al (2019)). The number of theoretical papers[4] is quickly growing while the structure of these research areas or their main directions are not quite established yet. Both of these areas are parts of FinTech that refers to various financial technologies used to automate process in the financial sector (Alt, Beck and Smits (2018), Das (2019), Horvat and Bobek (2020)). Crowdfunding is a fundraising strategy that aims in getting support from a large number of investors/funders ("crowd"). There are 4 main types of crowdfunding: reward-based crowdfunding, equity-based crowdfunding, debt-based crowdfunding and donation-based crowdfunding. Under reward-based crowdfunding, funders receive some benefits usually related to future firm products/services e.g. significant price discounts. Reward-based crowdfunding is offered in one of two models: KIA ("Keep-It-All") and AON ("All-Or-Nothing"). Under KIA the firm keeps the total amount raised. Under AON the firm sets a fundraising goal/target and keeps nothing if the target is not reached. Largest crowdfunding platform (Kickstarter) follows AON. Under equity-based crowdfunding investors receive shares of the company. Debt-based crowdfunding (also called P2P: peer-to-peer lending) involves requesting support and resources from other investors in exchange for interest. Under donation-based crowdfunding funders support the firm mission (usually related to social or environmental purposes) without getting any (direct) rewards.

Innovative companies can issue different types of tokens. These include ICOs (initial coin offerings), STOs (security token offerings), IEOs (initial exchange offerings) and NFT (non-fungible tokens).[5] Under ICO, a firm pre-sells utility tokens which give their holders the right to purchase the company's product/service when it becomes available. Under STO, a firm raises capital by selling tokenized traditional securities (security tokens) e.g. equity where tokenholders obtain rights on the firm's profit. Security tokens are often regulated (Ante and Fiedler (2019)). Under IEO, a firm raises funds by selling tokens with help of organized exchange (usually an exchange for cryptocurrencies such as Binance).[6] The exchange is

[4] For a review of literature on crowdfunding and tokens issues see, for example, Moritz and Block (2014), Mochkabadi and Volkmann (2018), Howell, Niessner, and Yermack (2019), Bao and Roubaud (2022) and Chalmers, Fisch, Matthews, Quinn and Recker (2022). Unlike these reviews the present review is specifically focused on theoretical papers. Also Hoegen, Steininger and Veit, (2018) focus on comparison of crowdfunding and traditional financing. See also Ahlers, Cumming, Guenther and Schweizer (2015), Belleflamme, Omrani and Peitz (2015), Estrin et al (2018) and Miglo (2021b).

[5] Tönnissen, Beinke and Teuteberg (2020) and Bachmann, Drasch, Fridgen, Miksch, Regner, Schweizer, and Urbach (2021) provide a description of different business-models/ideas related to firms that use tokens.

[6] Myalo (2019).

involved in promoting the firm tokens.[7] Unlike traditional cryptoassets NFT typically cannot be traded on interchangeable basis since they are unique and non-divisible. They are often used in trading, for example, piecies of arts.[8]

The analysis shows that 5 following ideas/topics dominate theoretical literature on crowdfunding and token issues.

1. *Learning market demand*. Under demand uncertainty, crowdfunding and token issues help entrepreneurs receive valuable signals and learn information about potential interest/demand for new products/services (Strausz (2017), Chemla and Tinn (2019), Schwienbacher (2018), Catalini and Gans (2018), Ellman and Hurkens (2016)). Learning can take different forms. Firms can learn from observing pre-orders under reward-based crowdfunding, by observing share price under equity-based crowdfunding, by observing the results of crowdfunding campaigns of their competitors, by receiving direct feedback from market participants etc. Similar ideas exist with regard to token issues. Firms can learn by observing and analyzing the demand for firm tokens, by observing the token secondary market price etc.

2. *Signalling project quality*. The projects of innovative firms and small- and medium- sized firms are in most cases projects with a very high degree of uncertainty regarding their quality. Unlike large established firms these firms or products do not have large media coverage or analyst coverage etc. In these conditions firms try to undertake some actions that can be interpreted as credible signals of their projects quality that should help them attract the maximal number of potential investors/funders (Miglo and Miglo (2019), Chakraborty and Swinney (2021), Sayedi and Baghaie (2017), Kim, Newberry and Qiu (2018), Chod and Lyandres (2021)). Firms can use different tools and ideas for signaling including an appropriate choice and design of their financing method. It includes the choice between traditional methods and new methods; the choice between different types of crowdfunding; the choice between different types of tokens; the choice of campaign target etc.

[7] ICO and IEO report (2020).
[8] Unlike ICO, STO and IEO, NFTs usually are used for trading purposes. There are however some cases where they were used for raising funding (see eg. Cases of *Stoner Cats* and *The Gimmicks* https://www.lexology.com/library/detail.aspx?g=a2d91fc1-b441-4f6a-9b61-a9a4a14c68a5)

3. *Network benefits*. Crowdfunding process and token issues are very different from traditional methods of fundraising by entrepreneurial firms. Among others these differences include exchange of information/feedback between funders and between funders and firms; a feeling of "community value" from being a part of large group of participants with similar motivations; ability to help with mitigating/solving communication/coordination problems between participants etc. Some theoretical papers focus on the analysis of these so-called "network benefits" of crowdfunding and token issues (Li and Mann (2018), Sockin and Xiong (2020), Bakos and Hałaburda (2018), Cong, Li and Wong (2021)).

4. *Mitigating moral hazard problems*. Some papers analyze the role of moral hazard in crowdfunding and token issues (Strausz (2017), Schwienbacher (2018), Chemla and Tinn (2019), Babich, Marinesi and Tsoukalas (2019), Belavina, Marinesi and Tsoukalas (2020), Garrat and Oordt (2019)). Moral hazard refers to situations where the actions of managers/entrepreneurs are not observable or non-verifiable by investors. Two types of moral hazard problems are dominating theoretical literature on crowdfunding and token issues: one related to entrepreneurial costly effort and one related to possible diversion of funds by entrepreneur. As an example, note that under equity-based crowdfunding, the entrepreneur`s share of the company is less than 100% (in the spirit of Jensen and Meckling (1976)) after funds are raised and therefore the entrepreneur`s incentive may be different than it would be, for example, under reward-based crowdfunding.

5. *Role of behavioural biases*. Behavioural finance is a growing and one of the most recently developed part of finance research. It is based on the idea that in many situations, decision-makers are not fully rational. The reasons might be very different including estimation mistakes, overconfidence, emotions etc. A growing line of theoretical research on crowdfunding and token issues focuses on the analysis of the role of these biases (Fairchild et al (2017), Belleflamme et al (2013, 2014)). For example an overconfident entrepreneur can set-up a target of crowdfunding campaign too high that can ultimately affect the probability of project success.

As was mentioned previously no paper has been specifically focused on reviewing theoretical literature on crowdfunding and token issues. This determines the significance of the present research. Also it is necessary to compare theoretical and empirical literature and find gaps and misalignments. So the aims and objectives of this article include the following: 1) to review theoretical literature in the areas of crowdfunding and token issues; 2) to determine common

approaches and common ideas and to determine which ideas have received high and low amounts of attention and respectively to determine under-researched areas; 3) to compare the results of theoretical papers with existing empirical papers and identify gaps and "grey" areas and ultimately suggest some ideas for future directions of research.

In terms of methodology used probably the closest paper is one by Harris and Raviv (1991) that provides a review of theories of capital structure. The papers are selected mainly based on the criterion that they offer rigorous theoretical models (usually in the context of financing literature it means using game-theoretic tools, contract theory tools etc.). To search articles the author has used the help of most academic search engines including Google Scholar, Webscience, SSRN etc. using words crowdfunding, token issues and other related terms. In addition some general papers in the area of financing have also been included because their ideas can be applied to the areas of crowdfunding and token issues without specifically mentioning it. Finally some working papers may have not being included because they seem to be in intermediate stages or have models from different areas eg. have different kinds of econometric or quantitative models that are not suitable for this research (in some cases the frontier separating different type of models is not quite clear so the author used his own judgement about whether to include a paper in this review). An important part of the analysis was to connect empirical papers and theoretical ones (these connections are summarized in Tables 1-5). Many of empirical papers do not directly test existing theoretical models but their results seem to be consistent with he spirit of these models predictions.

In terms of review organization, it is structured according to 5 main topics mentioned above. Each of these ideas has a separate section. Each section contains a simple micromodel illustrating some of the most important points. All other ideas are summarized in a separate section. Note that novadays most papers use more than one major factors of analysis unlike say capital structure theory developments in 1970-1990s when most papers had one major factor such as asymmetric information, moral hazard etc.[9] Now it is usually a combination of several factors. So some papers will mentioned in more than one section.

[9] Crowdfunding and tokens issues are methods of raising funds for firms so some of the ideas behind crowdfunding and token issues are related to capital structure theories. For a review of major capital structure theories see, among others, Harris and Raviv (1991) and Klein et al (2002). Note that these theories usually focus on firm choice between traditional debt and equity. We discuss connections between traditional theories and their possible applications to crowdfunding and token issues in Section 7.

The rest of the paper is organized as follows. Section 2 reviews literature related to "learning market demand" idea. Section 3 analyses signaling idea. Section 4 analyses network benefits. Sections 5 focuses on moral hazard problems. Section 6 discusses the behavioural aspects of crowdfunding and token issues. Section 7 reviews other theories and Section 8 provides a summary and a conclusion.

2. Learning market demand

One of the most popular ideas of crowdfunding and token issues is that firms can use them to learn information ("crowd wisdom") about the market. This section discusses articles that have element of "learning" at their models. Learning means that a firm/entrepreneur improves its information about market demand during crowdfunding or token issue (or some stages of crowdfunding/token issue process) and uses it later.

The following model illustrates this point.[10] Consider a firm with an innovative product or service. The production is q. The expected spot market price is p. The firm can also use a crowdfunding campaign (the product price during the campaign is p_c). The firm should determine c and s that are crowdfunding pre-sales and spot sales respectively: $q = c + s$. The inverse demand function is $p = a - q = a - c - s$. We assume a no-arbitrage environment, i.e. in equilibrium $p_c = p$. However, if the firm uses crowdfunding, the funders expect to receive an extra-benefit (reward) β from the firm that reflects the cost of waiting. Also the firm faces demand uncertainty: $a = a_h$ with probability μ and otherwise $a = a_l$, $a_h > a_l$.

Without crowdfunding (i.e. $c = 0$), when selecting s, the firm maximizes its expected profit from spot sales, which equals $\mu p_h s + (1-\mu)p_l s = \mu(a_h - s)s + (1-\mu)(a_l - s)s$. Here $p_h = a_h - s$ is the price when the demand is high and $p_l = a_l - s$ is the price when the demand is low. The solution is:

$$s = \frac{\mu a_h + (1-\mu)a_l}{2}$$

The firm's expected profit is

$$\frac{(\mu a_h + (1-\mu)a_l)^2}{4} \quad (1)$$

[10] In the spirit of Miglo (2020).

With crowdfunding (i.e. when $c > 0$), the firm gets to know the demand after crowdfunding campaign because the firm can observe p_c, which reflects the true value of a. If after crowdfunding the firm realizes that $a = a_h$ then the firm selects s to maximize $(a_h - c - s)s$.

The solution is:

$$s_h = \frac{a_h - c}{2}$$

Also

$$p_h = a_h - c - s_h = \frac{a_h - c}{2}$$

Similarly when $a = a_l$, we get $s_l = p_l = \frac{a_l - c}{2}$.

When preparing its crowdfunding campaign, the firm's expected profit equals

$$\mu(Ep_h(c + Es_h) - \beta c) + (1 - \mu)(Ep_l(c + Es_l) - \beta c) = \mu(a_h - s)s + (1 - \mu)(a_l - s)s =$$

$$= \mu\left(\left(\frac{a_h - c}{2}\right)\left(\frac{a_h + c}{2}\right) - \beta c\right) + (1 - \mu)\left(\left(\frac{a_l - c}{2}\right)\left(\frac{a_l + c}{2}\right) - \beta c\right) = \frac{(\mu a_h^2 + (1-\mu)a_l^2 - c^2)}{4} - \beta c \qquad (2)$$

Here Ep_h and Ep_l are price expectations for the scenario with high- and low- market demand respectively. Given the no-arbitrage condition, these expectations should be equal to expected spot sale prices. The difference between (2) and (1) can be written as

$$\frac{\mu(1-\mu)(a_h - a_l)^2}{4} - \frac{c^2}{4} - \beta c \qquad (3)$$

If c is sufficiently small, crowdfunding provides higher profit than spot sales alone. Indeed consider an extreme case $c = 0$. In this case (3) becomes $\frac{\mu(1-\mu)(a_h - a_l)^2}{4}$ which is strictly positive and therefore by the continuity of profit functions in c the same holds if c is sufficiently small. So crowdfunding can create value for the firm.

Degree of uncertainty about market demand. If the difference between a_h and a_l increases then the likelihood that (3) is positive increases. With regard to the value of μ note that (1) is maximized when $\mu = 1/2$. This is the case when the level of uncertainty is highest, i.e. high and low demand are equally likely. Both these points mean that the likelihood of crowdfunding increases when uncertainty regarding market demand increases.

Chemla and Tinn (2019) develop a model where crowdfunding (reward-based) helps firms receive valuable information about their projects. Crowdfunding allows them to learn about the total demand from a sample of consumers (funders). They predict that higher degree of uncertainty is positively correlated with the benefits of reward-based crowdfunding. They present data that support their results based on the comparison of crowdfunding campaigns by technology firms (with a higher degree of demand uncertainty) and theatre firms. It is also consistent with the spirit of findings in Xu (2017).

Similar ideas can be used with regard to ICO analysis. Entrepreneurs learn information about market demand by observing the price of tokens issued during ICO. One can argue that ICO will be preferred to STO if the degree of demand uncertainty is relatively large (Miglo (2021a)). It is indirectly consistent with the spirit of Amsden and Schweizer (2018). Based on an analysis of 1,009 projects between 2015 and 2017 Amsden and Schweizer (2018) argue that ICO projects are characterized by a very high degree of market uncertainty.

Schwienbacher (2018) studies risks related to crowdfunding. It includes the uncertainty of market demand. Reward-based crowdfunding provides valuable information. On the other hand, raising funds from traditional investors does not offer the same level of feedback, since usually their decisions are based on the expected overall profitability of the project and not on consumption. Schwienbacher (2018) also finds that crowdfunding is more likely when demand uncertainty is higher.

Project size. (3) is positive only if c (size of crowdfunding campaign) is relatively small. This is intuitive since the firm is facing a trade-off between learning market demand and paying benefits β to funders. If we assume that funds raised during crowdfunding campaign should also cover some one-time investment costs, this result leads to the prediction that crowdfunding (reward-based crowdfunding) will be preferred strategy for relatively small investment projects.

Chemla and Tinn (2019) predict that smaller campaign size (they interpret it as a shorter campaign duration) is associated with a higher probability of crowdfunding success and as such is positively correlated with the attractiveness of crowdfunding that is consistent with the spirit of above point. This is also consistent with empirical findings in Mollick (2014).

Ellman and Hurkens (2016) analyze optimal design of AON campaign when a firm faces consumers with high and low-valuation of its product. The model predicts that crowdfunding campaigns should have moderate size. Also crowdfunding is complimentary to traditional

financing when fixed costs are large. The model also predicts that crowdfunding prices are lower than future spot sale prices.

Chen, Gal-Or and Roma (2018) consider a model where an entrepreneur designs a reward-based crowdfunding campaign that helps him and helps a venture capitalist (VC) as well learn information about demand. The project size is supposed to be sufficiently large so VC participation is required. They find that entrepreneurs should use crowdfunding either when it is highly informative or when it is not informative at all. Otherwise the benefits of crowdfunding cannot offset the risk of campaign failure. The authors also find that successful campaigns do not necessarily lead to a VC funding.

In Catalini and Gans (2018) an ICO allows an entrepreneur to reveal consumer value via competition among potential buyers without the entrepreneurs having to know, ex ante, consumer willingness to pay. This paper also predicts that initial funds raised are maximized by setting the growth in the supply of tokens to zero to encourage early investments.

Among other theoretical predictions note the following. Sahm (2016) investigates a model of advance-purchase contracts (eg. crowdfunding) and compares it with traditional financing. The model finds that advance-purchase arrangements are preferable for large size projects. Strausz (2017) argues that the extraction of information about market demand has its drawbacks and that the entrepreneur should learn neither too much nor too little.

The main articles analyzing the learning the market demand idea, their predictions and empirical evidence are summarized in Table 1.

Table 1. Learning-based theories of crowdfunding and token issues

Paper	Predictions	Direct tests	Indirect evidence
Schwienbacher (2018)	Crowdfunding is preferred to venture capital if demand uncertainty is high		
Chemla and Tinn (2019)	Higher uncertainty of demand increases profitability of crowdfunding; smaller campaigns (shorter duration campaigns) have higher probability of success; prices are smaller during crowdfunding compared to spot sales		Xu (2017), Mollick (2014), Chemla and Tinn (2019)
Miglo (2021a)	ICO is more likely than STO if demand uncertainty is higher		Amsden and Schweizer (2018)

Strausz (2017)	The amount of information learned by the firm during crowdfunding should not be too low or too high		
Ellman and Hurkens (2016)	Crowdfunding campaigns should have moderate size; prices are smaller during crowdfunding compared to spot sales; crowdfunding and traditional finance are complements when fixed costs are large and crowdfunding is a substitute for credit when fixed costs are small		Mollick and Kuppuswamy (2014)
Sahm (2016)	Large projects prefer crowdfunding compared to traditional financing		
Catalini and Gans (2018)	ICO helps reveal consumers' willingness to pay; ICO will be preferred to equity financing if the amount of required investment is not too large		
Chen, Gal-Or and Roma (2018)	Entrepreneurs should use crowdfunding either when it is highly informative or when it is not informative at all; successful campaigns do not guarantee subsequent VC funding		

3. Signaling project quality

Another important idea is that firms/entrepreneurs use crowdfunding or token issues to signal quality or other features of their projects. As was mentioned previously, entrepreneurial and innovative businesses and their projects often represent an "unread" book for market participants. Entrepreneurs try to mitigate informational problems either directly by communicating to the public the description of their activities and new projects or indirectly by selecting actions which may have a favourable interpretation by potential investors.[11] This section discusses articles that have an element of "signalling" in their models that is usually based on firms selecting an appropriate financing/fundraising strategy.

To illustrate the idea, consider the following model. Consider a firm with an innovative product or service. Predicted sales of the product equal a. The cost of production equals c. There are two firms: a low-cost (high-quality) firm (L) and a high-cost (low-quality) firm (H). The cost of production is c_h for H and c_l for L, $c_h > c_l$. The firm does not have any initial

[11] The former has its limits i.e "actions speak louder than words". See Lincoln (1856). https://www.bookbrowse.com/expressions/detail/index.cfm/expression_number/151/actions-speak-louder-than-words. See also Grinblatt and Titman (2001) and Miglo (2021b).

resources. To finance the production of the product, firms can use reward-based crowdfunding or equity financing (including equity-based crowdfunding or traditional equity). Consider perfect information scenario. Under reward-based crowdfunding the firm's profit is $a - c_i$. Under equity financing the firm's expected profit equals $(1 - \alpha)(a + M - c_i)$, where M is the amount of funds raised and α is a fraction of firm's equity sold to investors. In order to assure that investors provide funds, the following constraint must be satisfied: $\alpha(a + M - c_i) \geq M$. The solution is: $M = c_i, \alpha = c_i/a$. The firm's profit equals $a - c_i$. Note that both strategies can only work if $c_i < a$ and secondly they have the same result for the firm (not surprising given a perfect market environment with symmetric information (Modigliani and Miller (1958)). Now consider asymmetric information.

Consider an equilibrium where H selects equity financing and L selects crowdfunding. H's profit equals $a - c_h$ as previously. If it decides to mimick L and selects reward-based crowdfunding its payoff is the same $a - c_h$. Private information is related to the cost of production and not to the demand side, hence it does not affect the outcome of reward-based crowdfunding. Firms will select their prices as in the case with symmetric information since the demand function is the same for any type of the firm. Under reward-based crowdfunding, funders receive products and do not rely on any long-term firm profits. Under equity-crowdfunding, investors/funders count on long-term profits of the firm (which are directly affected by firm costs) and it is reflected in share price during crowdfunding campaign. So if the low-quality firm (high-cost) firm uses equity-based crowdfunding it will not be mimicked by the high-quality firm. Indeed L's equilibrium payoff is $a - c_l$. If L mimicks H, then market participants think that this is type H. Note that in equilibrium $\alpha = c_h/a$ and $M = c_h$. L's payoff from mimicking H equals then $(1 - \alpha)(a + M - c_l) = \left(1 - \frac{c_h}{a}\right)(a + c_h - c_l)$. After simplifications we find that this is less than $a - c_l$ because $c_l < c_h$. So L will not mimick H and such an equilibrium exists.

On the contrary an equilibrium an equilibrium where L selects equity financing and H selects crowdfunding does not exist because H will mimick L. Indeed H's profit equals $a - c_h$. H's payoff from mimicking L equals (calculations are identical to these above) $\left(1 - \frac{c_l}{a}\right)(a + c_l - c_h)$. After simplifications we find that this is less than $a - c_h$ because $c_l < c_h$. So H will mimick L and such an equilibrium does not exist.

Choice of financing strategy. The above analysis predicts that firms can use crowdfunding as a signal of quality. More specifically it predicts that asymmetric information favors reward-based crowdfunding. Miglo and Miglo (2019) analyze the firm choice between reward-based crowdfunding and equity-based crowdfunding and find that high-quality firms prefer reward-based crowdfunding as a signal. It would be interesting to apply similar ideas to the choice between ICO and equity financing under imperfect information. High-quality firms can use ICO as a signal. The reason is that prices, production decisions and other parameters arising in equilibrium for a high-quality firm may not be suitable for a bad quality firm if the latter decides to mimick the high-quality firm. Note that Bourveau et al (2018), De Jong et al (2018), Ofir and Ido (2019) and Benedetti and Kostovetsky (2021) suggest that in order to be successful, an ICO should meet high quality standards including the quality of "whitepapers" (technical documentation describing ICO), good level of transparency etc.

Fraction of equity retained by the entrepreneur. Our analysis implies that high-quality entrepreneurs will retain a higher fraction of equity in equilibrium compared to low-quality type (reward-based crowdfunding does not reduce entrepreneurs' fraction of equity). To the best of our knowledge, this prediction has not been tested directly but is consistent with the spirit of Ahlers et al (2015), Mollick (2014) and Vismara (2016) that the firm's financing choice can serve as a signal of firm quality and also that the entrepreneur's fraction of equity is associated with a higher quality. This idea can be extended to the case of token issues as well. Chod and Lyandres (2021) compare ICO with traditional equity-based financing (venture capital or VC), focusing on several factors including information asymmetry between entrepreneurs and investors. In their model asymmetric information between firm and investors exists in the case of ICO but not in the case of VC. They show that ICO can be by high-quality entrepreneurs by retaining more tokens in their won possession (signaling by risk-bearing in the spirit of Leland and Pyle (1977)).

Some papers analyze signaling opportunities by selecting a different type of reward-based crowdfunding, namely the choice between AON and KIA. It is mostly based on the main feature of AON specially a condition that if a campaign target (threshold) is not reached, money are returned to funders/investors. This analysis also implies that when asymmetric information is important, high-quality projects prefer AON. Miglo and Miglo (2019) consider a model of the choice between reward-based crowdfunding (AON and KIA) and equity-based crowdfunding when private information concerns the product quality (and respectively future demand for the

product). It is shown that an efficient signaling in one-period environment is impossible because a high-quality frim will always be mimicked by low-quality firm. Then the authors analyze a two-period environment. It is shown that under some conditions high-quality firms can use AON as a signal of quality. A low-quality firm may find it unprofitable to mimick this strategy as it will be taking more risk to achieve a threshold by deleting potential income in the second period may be too high, which can be costly in the second period. This prediction has not been directly tested but is consistent with the spirit of Cumming, Leboeuf and Schwienbacher (2019) that find that KIA campaigns are less successful in meeting their fundraising goals compared to AON. For example, the rate of success of campaigns on Kickstarter, which only uses AON, is higher than on Indiegogo.[12]

Some papers are focused on signalling opportunities related to campaign target/threshold. To illustrate the idea, consider the following model. There are two firms: a low-quality firm (L) and a high-quality firm (H). The objective of each firm is to maximize the amount of funds collected during crowdfunding campaign. Under perfect information about the firm's type L can collect an amount a and H can collect b, $b > a$. Firms have two strategies: first is AON (that as we know is characterized by a campaign target/threshold) and the second strategy under which a threshold is not established (for example KIA, equity-based crowdfunding, traditional debt or equity etc.). If AON is selected, there is risk that funds will not be collected above an established threshold, in which case the campaign fails. This happens with probability $1 - p_1$ for type L and $1 - p_2$ for type H, $p_1 < p_2$. If information is asymmetric, a separating equilibrium with H using strategy 2 does not exist. Indeed if such an equilibrium exist and H raises an amount b and L raises a (in a separating equilibrium firm types are revealed to the public so the outcome is identical to the case with perfect information). But in this case L mimicks H because the market thinks that strategy 2 is selected by high-quality type. Therefore L will be able to raise an amount b. Since $b > a$, such an equilibrium does not exist. Now consider a separating equilibrium where H selects AON and L selects strategy 2. The expected amount of funds raised for H is $p_2 * b$ and that of L it is a. If L decides to mimick H and play AON, its expected payoff is $p_1 * b$ which can be smaller than a if $p_1 < a/b$. If H mimicks L and selects strategy 2, its payoff is a. This is smaller than $p_2 * b$ if $p_2 > a/b$. So a separating equilibrium exists if

[12] See, for example:
http://crowdfunding.cmf-fmc.ca/facts_and_stats/how-likely-is-your-crowdfunding-campaign-to-succeed

$$p_2 > a/b \text{ and } p_1 < a/b \quad (4)$$

which is possible because $p_1 < p_2$ and $a < b$.

Choice of threshold. Our analysis implies that high-quality firms can use AON to signal their quality. If (4) holds then the threshold (assuming H selects b as a threshold) increases with firm quality. This is because mimicking will be unprofitable for a low-quality firm because it would imply a high risk of campaign failure. Chakraborty and Swinney (2021) consider a model where an entrepreneur has private information about its firm product quality. It is found that a large size campaign should be used by high-quality entrepreneurs. At the same time, Miglo and Miglo (2019) find that the relationship between a firm's quality and the campaign threshold is non-linear. They argue that the threshold should be neither very small nor very large. Note that Mollick (2014) and Cordova and Dolci (2015) find that larger targets do not lead to greater rates of success. Further research is required.

Signalling and the extent of asymmetric information (uncertainty about project quality). (4) predicts that signaling opportunities exist when the extent of asymmetric information is large enough. Indeed for any given value of p_1 farther is p_2 from p_1 then it is more likely that a separating equilibrium exists. Similarly for a given value of p_2 an equilibrium exists if p_1 is farther from p_2 or if p_1 is sufficiently small. Some empirical research suggests that it is very typical in crowdfunding for projects to attract very low or negligibly small amounts of funds (see, for example, Mollick (2014), Cordova and Dolci (2015) and Desjardins (2016)). So the condition that p_1 should be sufficiently small is not unreasonable.

Among other papers note the following. Hakenes and Schlegel (2014) analyze a model that compares traditional bank financing and debt-based crowdfunding. Compared with traditional loans, under crowdfunding good projects have more opportunities to receive funding. On the other hand, under crowdfunding entrepreneurs will establish low loan rates loan rate and low thresholds threshold, that will generate too much information.

Kim, Newberry and Qiu (2018) show that the amount of funds raised and the number of backers during the campaign have a nontrivial impact on the efficiency of crowdfunding. They present a model of funder behavior on a crowdfunding platform and show that the campaign

funding status and the number of funders-per-day positively affect the funder's utility. They then test their model and that first both signals have nontrivial impacts, and second the funding status has a larger impact on the efficiency of outcomes.

Sayedi and Baghaie (2017) argue that both a small threshold and a high price should be used by the founders. Quite surprisingly, they also find that lack of information about entrepreneurs leads to higher product qualities. Funders therefore benefit from an environment with asymmetric information and unceratinty.

In all considered above papers entrepreneurs send signals of their projects qualities to potential investors or to the crowd. Some papers analyze a different type of signalling. Chen et al (2018) consider a model where a reward-based crowdfunding campaign set up by an entrepreneur with a large innovative project serves as a signal of demand to a venture capitalist (VC). The participation of VC is required for the entrepreneur because he needs a large amount of investments followed by a crowdfunding campaign. Similarly crowdfunding can be used by firm to signal the quality of their firms to competitors (Miglo (2020)). Low-quality firms would not necessarily mimic high-quality firms because this would imply a high cost of rewards rewards.

Table 2. Signalling theories of crowdfunding and token issues

Paper	Predictions	Direct tests	Indirect evidence
Miglo and Miglo (2019)	High-quality firms use reward-based crowdfunding as a signal compared to equity-based crowdfunding; high-quality firms use AON as a signal compared to KIA; non-linear relationship exists between target and firm quality; reward-based crowdfunding campaigns have smaller size compared to equity-based crowdfunding; prices are higher and quantities are lower with crowdfunding		Cumming, Leboeuf and Schwienbacher (2019), Ahlers et al (2015) and Mollick (2014), Cordova and Dolci (2015), Paakkarinen (2016) Tuo, Feng, Sarpong and Wang (2019), Gabison (2015)

Chakraborty and Swinney (2021)	High-quality firms use higher campaign targets as a signal of quality		Devaraj and Patel (2016), Tuo et al (2019)
Sayedi and Baghaie (2017)	A low campaign goal and a high pre-order price are positively correlated with quality; uninformativeness can be beneficial; high-quality producer's optimal strategy may be to opt out of the crowdfunding market		Koch and Siering (2019)
Hakenes and Schlegel (2014)	Target is too low and the interest rate is too low under debt-based crowdfunding		
Kim et al (2018)	For AON projects funding status is a strong signal	Kim et al (2018)	
Chen, Gal-Or and Roma (2018)	Entrepreneur choses low target to signal quality to VC		
Chod and Lyandres (2021)	High-quality entrepreneurs retain more tokens during ICO		Davydiuk, Gupta, and Rosen (2019)

4. Network benefits

Another line of research focuses on networks benefits of crowdfunding and token issues. The following example illustrates the role of crowdfunding in overcoming coordination failure and equilibrium multiplicity. Suppose there are two prospective consumers/buyers of a firm product. Suppose the firm sells the product on the spot market and the price for the product is p. Each consumer gets an amount of benefits v if buying the product and $v + s$ if and only if the other consumer also buys the product where s is the network benefit (exchange of ideas, community sense etc.). Hence the matrix of payoffs is:

Player 1/Player 2	buy	not to buy
buy	$v + s - p, v + s - p$	$v - p, 0$
not to buy	$0, v - p$	0,0

There are two Nash equilibria in this (coordination) game if

$$v < p < v + s \tag{5}$$

either both investors participate in the campaign, or neither joins. The multiplicity of equilibria opens the door for social value loss.

Crowdfunding. If instead of using spot sales the firm presell the product using crowdfunding, potential buyers/funders can observe other funders strategies (eg. crowdfunding campaigns update information about the number of pre-sold items). In this case we can assume that the game becomes dynamic (and not strategic as described above). In this case the only equilibrium is one where both consumers participate. Similar idea can be applied to utility token issues.

Financing choice and the extent of community benefits. Crowdfunding or token issues are more likely for products with large community benefits. Indeed if s is sufficiently large then entrepreneurs have large opportunities to create profits. Indeed suppose that the cost of the product is c for the entrepreneur. In equilibrium entrepreneur's profit equals $2(p - c)$, where the maximal price that can be charged is $v + s - e$, where e is a sufficiently small number. So the entrepreneur's profit is $2(v + s - e - c)$. Higher s leads to higher profits for the entrepreneur. It is observed that tokens and crowdfunding are especially popular in sectors or segments of the market with large network benefits (Kromidha and Robson (2016), Brown et al (2019), Mourao et al (2018), Drasch, Fridgen, Manner-Romberg, Nolting and Radszuwill (2020)). Drasch et all (2020) further argue that the network benefits of tokens should be weighted by tokenholders against the upside potential of future token value growth.

Production cost and the choice of financing. As follows from (5) coordination problems under crowdfunding would be avoided if the production cost of the firm is either very small or very high. Indeed suppose that the cost per product is c. The product price should at least cover cost. If the cost is not sufficiently small and not very large, i.e if, for example, $v + s > c > v$ then the only situation when entrepreneur can male profit is $v < p < v + s$ which will imply equilibrium multiplicity. A similar situation can arise if the fixed cost of the campaign or crowdfunding fees are not sufficiently small.

Deb, Oery and Williams (2019) study reward-based crowdfunding campaigns. In their model two types of funders exist: some of them want to consume the product ("buyers") while others

just want the firm to be successful. There is a coordination problem among buyers, The paper describes possible equilibria in the game and provides a comparative analysis of factors affecting the probability of campaign success. Also the paper suggests that projects that finish close to the deadline are usually driven by the second type of funders while projects that finish early are primarily driven by the first type.

The ideas of coordination problems and multiplicity equilibria can be applied to token issues as well. Similarly to crowdfunding campaign, the benefits of ICO participants depends on the degree of other agents participation. Li and Mann (2018) present a model of ICO that has two features: on one hand an ICO solves a coordination failure inherent in many platforms with network effects; and on the other hand harness the "wisdom of the crowd" by aggregating dispersed information about platform quality. The model predicts that multiple stages of ICO (pre-sale of tokens, sales of tokens and launching a platform) is a part of optimal design. Multiple stages of ICO help mitigate coordination problems but also help mitigate difference in private values of different agents. Agents with highest values will move first end their actions will motivate users with lower valuations etc. Universal ban on ICO is not optimal. Also the model is consistent with the point that an ICO can quickly attract a large number of investors.

Sockin and Xiong (2020) develop a model to analyze the determinants of the fundamental value of a token. They argue that the trading price and volume of the cryptocurrency help with aggregating private information about cryptocurrency fundamentals and secondly they also facilitate coordination in equilibrium. Bakos and Halaburda (2018) develop a model to investigate the use of tradable digital tokens to solve a coordination problem. They show that tokens have higher value if the platform succeeds and help with supporting equilibria favorable to the platform. They also argue that pure utility tokens have certain characteristics of equity because the buyers of tokens enjoy the future gains if the platform succeeds.

Among other ideas note the following.

In Belleflamme et al (2014), participants of crowdfunding campaigns enjoy community benefits. It is argued that equity-based crowdfunding should be preferred by large projects.

Catalini and Gans (2018) analyze a model that compares ICO and equity financing. In their model tokens can mitigate coordination problems among partcipants in the presence of network effects.

Cong, Li and Wong (2018) provide a dynamic asset-pricing model of (crypto-)tokens on (blockchain-based) platforms. In their model network benefits increase with the size of platform. Large size means that more community benefits can be realized by users using the platform. Agents decisions about how many tokens to buy etc. have externality effect on all agents. They compare traditional selling of products without tokens and platform with tokens. They argue that tokens are more likely if technical progress is expected. In this case the token price is expected to grow and attract more users since they can also use tokens as a saving device. They also predict that token price is non-linearly correlated with platform productivity, user heterogeneity, and network size.

Some papers started to analyze a different type of network advantage of crowdfunding. Namely it can also benefit firms operating in a competitive network with multiple producers. The following illustrates the idea. Consider a firm that can choose between selling its product on a spot market (value is v) and via crowdfunding ($v - \beta$). Buyers are rewarded a benefit β for waiting, $\beta < v$. There are four potential buyers. If sales include two stages (crowdfunding and spot sales) buyers are split 50-50 between first and second stages. Without crowdfunding, the firm's expected profit is $4v$. With crowdfunding the firm's expected profit equals $4v - 2\beta$. Since the former is greater than the latter, crowdfunding is useless under monopoly (one firm).

Now consider the case with two firms. Suppose that if two firms are on the spot market, buyers are split 50-50 between firms. In stage 1 the following situations can occur: both firms select spot sales (denote this strategy S); both firms select crowdfunding (denote this strategy CF); Firm 1 selects CF and Firm 2 selects S; Firm 2 selects CF and Firm 1 selects S. If both firms select S, the equilibrium firms' profits are $\pi_1 = \pi_2 = 2v$. If both firms select CF, the equilibrium firms' profits are $\pi_1 = \pi_2 = 2v - \beta$. Indeed in this case each firm gets two buyers: one of them pre-orders the product during crowdfunding. Now consider the case when one firm (suppose Firm 1) selects CF and Firm 2 selects S. During crowdfunding Firm 1 pre-sells two goods and on the spot market 2 remaining buyers are split 50-50 between firms. So Firm 1's profit equals $3v - \beta$ and Firm 2's profit equals v.

Then the matrix of payoff will become:

Firm 1/Firm 2	S	CF
S	$2v, 2v$	$v, 3v-\beta$
CF	$3v-\beta, v$	$2v-\beta, 2v-\beta$

Since $v > \beta$, the only equilibrium is one where both firms use crowdfunding.

Table 3. Network benefits theories of crowdfunding and token issues

Paper	Predictions	Direct tests	Indirect evidence
Belleflamme et al (2014)	Crowdfunding price is higher than sale price; Equity-based crowdfunding projects are larger than reward-based crowdfunding projects; asymmetric information favors equity-based crowdfunding		
Catalini and Gans (2018)	Size of projects with ICO is smaller compared to traditional equity financing		
Li and Mann (2018)	Multi-period trade is preferred to one-stage trade; universal ban on ICO is not optimal; ICO can quickly attract a large number of investors		
Sockin and Xiong (2020)	A rising token price is positively correlated with higher fundamental in the high price equilibrium, while it is indicative of lower fundamental in the low price equilibrium; technical analysis may lead to erratic trading behavior		
Bakos and Hałaburda (2018)	ICO is preferred to traditional financing if the firm is capital constraint		
Cong, Li and Wong (2018)	Tokens are more likely if technical progress is expected.		
Deb et al (2019)	The distribution of campaign completion times is U-shaped; Projects that fail often fail with only a small amount raised; tend to drop off sharply after a campaign meets its funding goal, while purchases continue	Deb et al (2019)	

Drasch et all (2020)	Two-sided incentives for platform participants: on one hand, the increasing number of platform participants results in an increase of the token value during platform operation; on the other hand, this benefits can weigh against token price growth potential		Haffke and Fromberger (2018), Momtaz (2019)

A new/growing line of research is related to donation-based crowdfunding that uses coordination problems/network effects ideas. Argo, Klinowski, Krishnamurti and Smith (2020) argue that non-observability of other donors contributions implies the uncertainty about the recipient ability to collect a necessary amount of funds that companied with and/or private benefits from the fact of making a deciding contribution to the projects can improve the campaign outcome for donation-based crowdfunding. Cason and Zubrikas (2019) argue that all-or nothing feature of crowdfunding (refund bonuses) can also improve the coordination problems and ultimately can improve the outcome of donation-based crowdfunding.

In terms of future research one can apply network ideas to analyze the choice between ICO and IEO. For many entrepreneurs this issue seems to be very important.[13] One can argue that IEO will be preferred if the promotion effect of listing (which is related to accessing a larger network of potential investors) is sufficiently large and when investment size is relatively large. Khatib (2019) reports that the average size of IEO is $US17 million while the average size of ICO is $US10 millions. Similar data can be found in ICO and IEO report (2019).

5. Mitigating moral hazard problems

Moral hazard refers to situations where the actions of managers/entrepreneurs are not observable and/or not verifiable by investors. Two types of moral hazard seem to be dominating theoretical literature on crowdfunding and token issues: one is related to entrepreneurial costly effort (in the spirit of Jensen and Meckiling (1976)) and the other one is related to possible diversion of funds by entrepreneur (in the spirit of Jensen (1986)).

5.1 Moral hazard related to entrepreneur's costly effort

[13] See, for example, Khatib (2019).

Under AON, the entrepreneur`s payoff is risky so when choosing his level of effort he is facing a trade-off between marginal cost of effort (the entrepreneur bears 100% of the cost increase) and expected benefits which are weighted by the risk of campaign failure. In these conditions entrepreneurs of high-quality ventures will be providing more effort than those of low-quality ventures.

The following model illustrates this point. Consider a firm with an innovative product or service. The firm is run by an entrepreneur who can provide either high or low level of effort during the campaign of raising funds. Let c be the cost of effort. If the effort is high ($c = e$), the firm can raise an amount of B with probability p_h and 0 otherwise. If the effort is low ($c = 0$), the firm can raise A with probability p_l, $A < B$, $p_l < p_h$. We assume that both strategies have positive net-present value (NPV), i.e.

$$p_h B > e \quad \text{and} \quad A > 0 \tag{6}$$

(the latter implies that $p_l A > 0$). In addition if the campaign is successful, it will be second period of production during which the firm will generate profit $X + x$, where x depends on the crowdfunding campaign threshold. If the company sets a high threshold during the campaign it can generate more profits in period 2 since it creates more trust in the firm (and its product). The firm has 3 strategies: KIA; AON with threshold A; and AON with threshold B. We assume that $x = b$ if the threshold was B and $x = a$ if threshold was was A, $a < b$. $x = 0$ in the case of KIA.

The firm expected payoff under KIA is

$$p_h B + X - e \tag{7}$$

if the effort is high and

$$p_l A + X \tag{8}$$

if the effort is low. The firm's expected payoff under AON and threshold A is

$$p_h(B + X + a) - e \tag{9}$$

if the effort is high and

$$p_l(A + X + a) \tag{10}$$

if the effort is low. Finally under AON with a threshold B the profit is

$$p_h(B + X + b) - e \tag{11}$$

if the effort is high and 0 if the effort is low (a high threshold will not be reached if the effort is low). (6) implies that (11) is positive and therefore there is no sense to set a high threshold and undertake low effort because in this case the entrepreneur's payoff is zero. Next note that (11) is greater than (9). It implies that there is no sense to undertake a high effort and set a low threshold.

Two cases are possible. First consider $p_hB - p_lA > e$. This implies that (7) is greater than (8). It means that a high effort under KIA is better than a low effort. It also means that (11) is greater than (10) because $A < B$ and $p_l < p_h$ and $a < b$. So the choice for the entrepreneur is now between KIA with high effort and AON (threshold B) with high effort. If $p_h > X/(X + b)$ AON will be chosen and vice versa.

Now consider $p_hB - p_lA < e$. Then in turn two cases are possible. First consider $p_h(B + X + b) - e > p_l(A + X + a)$. Then the choice is between AON with high effort and threshold B and KIA with low effort. The former is preferred if

$$p_h(B + X + b) - e > p_lA + X \tag{12}$$

Second consider $p_h(B + X + b) - e < p_l(A + X + a)$. Then the choice is between AON with low effort and threshold A and KIA with low effort. The former is preferred if $p_l > X/(X + a)$.

Probability of success and crowdfunding type. The main prediction of the above analysis is that the only case when the entrepreneur selects different level of efforts for different types of

crowdfunding is one where he selects a high level of effort under AON (and a high threshold) and a low level of effort with KIA. Cumming et al (2019) suggest that KIA campaigns are less successful in achieving their objectives that is consistent with the spirit of above results. For example, the expected probability of success on Kickstarter that uses AON, is usually higher than that on Indiegogo.

Cost of effort and the extent of continuation benefits. The above choice (between AON with high threshold and high level of effort) and KIA with low level of effort depends on (18). As follows from (18), AON is more likely when the cost of effort is relatively low and the continuation effect are low in the scenario when the firm does not benefit from trust increase, i.e the value of X. If X is high then KIA is preferred. This is intuitive since KIA there is not risk to discontinue the firm.

Schwienbacher (2018) analyzes a model of choice between crowdfunding and venture capital that is based on moral hazard problems. Similarly to the spirit of analysis above the paper finds that under AON the best strategies are either to have a large target and deliver a high level of effort or a small target and a low effort. Entrepreneur prefers a former if the effort cost is relatively low or when the demand uncertainty is high. Also the entrepreneur prefers crowdfunding to venture capital if the effort cost is low or when the demand in low-demand scenario is very small. This is because continuation happens under VC more often than under AON, however this continuation maybe inefficient in a low-demand scenario if the demand is very low in this case. Schwienbacher (2018) also argues that firms increase their crowdfunding target if the risk of project discontinuation increases. This takes place for example when there is a risk that the idea can be mimicked by competitors. The presence of professional investors (business angels, venture capitalists) reduces the entrepreneurs' incentives in crowdfunding. On the other hand professional investors can reduce the entrepreneur's risk-taking that in turn implies that crowdfunding is a complement rather than a substitute to existing investors.

Among other papers note the following.

Babich, Marinesi and Tsoukalas (2019) study an optimal financing strategy for a start-up that can include crowdfunding, venture capital (VC) and traditional debt. A moral-hazard problem exists between an entrepreneur and a bank, and a double-sided moral-hazard problem exists between the entrepreneur and a VC (both sides are affected). Under crowdfunding the

entrepreneur should take into account the expected scenario after the campaign is finished including future financing opportunities. In some cases a successful campaign can reduce the firm chances with VC because it can worsen moral hazard problems. For example, it can be the case when the probability of project success is too high prior to bargaining with VC) or when the amount of funds raised during campaign is too large (overfunded project) that can exacerbate competition from banks and worsen the position of VC and ultimately the outcome of bargaining as well. The finding that VC can walk away after successful crowdfunding campaign is consistent with Ryu, Kim and Hahn (2019). Babich et al (2019) also suggest that the likelihood of negative effects of crowdfunding is high among projects with relatively low capital requirements.

Miglo and Miglo (2019) analyze the role of different market imperfections in crowdfunding including the effect of moral hazard issues on pricing and production strategies. Under equity-based crowdfunding the fraction of shares retained by the entrepreneur is reduced (in the spirit of Jensen and Meckling (1976)). Miglo and Miglo (2019) suggest that prices can be higher and quantity produced can be lower under equity-based crowdfunding than under reward-based crowdfunding. This seems to be indirectly consistent with, for example, Paakkarinen (2016) in that equity-based crowdfunding may have fewer customers, but higher margins. In more general terms, moral hazard issues related to the entrepreneurial effort might be more important under equity-based crowdfunding (see, for example, Gabison (2015) and also Paakkarinen (2016) that noted that equity-based crowdfunding is more constricted in comparison to other forms of crowdfunding).

Moral hazard ideas related to entrepreneurial costly effort can also be applied to the analysis of token issues. Garrat and Oordt (2019) study a model of ICO that includes entrepreneurial moral hazard. The model generates conditions when an ICO is preferred to traditional debt or venture capital. Garrat and Oordt (2019) find that an ICO can be the only strategy that induces an optimal effort. This is because under ICO, token value is not proportional to firm profit, the effect of moral hazard is different from traditional equity financing or debt financing. In particular if the entrepreneur effort leads to cost saving rather than revenue increase, ICO does not create any distortions in terms of effort choice.

Miglo (2021a) studies the choice between utility tokens and STO under moral hazard and demand uncertainty. Security tokens can help with improving the incentive of firm partners

including professional blockchain participants that are involved in the project (website platform) development. So STO will be preferred if the extent of moral hazard problems is larger than that related to the degree of uncertainty regarding market demand. Next Miglo (2021a) includes utility tokens with profit rights into the basic model and demonstrates that this type of token dominates regular utility tokens (i.e. without profit rights) or security tokens. This is indirectly consistent with Adhami et al (2018) that finds higher returns for firms when tokens provide additional services including profit rights.

Chod, Trichakis and Yang (2021) compare traditional equity financing and ICO in a model that includes entrepreneurial moral hazard since the entrepreneur's effort is costly. Their model also includes corporate governance considerations because it affects a potential hold-up problem related to the point that costs of participants joining the platform becomes sunk after being paid (for a model of choice between token issues and equity financing that includes entrepreneurial moral hazard see also Malinova and Park (2018) and Gryglewicz, Mayer and Morellec (2021)).

Table 4. Moral hazard-based theories of crowdfunding and token issues

Paper	Predictions	Direct tests	Indirect evidence
Schwienbacher (2018)	Crowdfunding is complimentary to venture capital financing rather than substitute; entrepreneur prefers crowdfunding to venture capital if the effort cost is low or when the demand in low-demand scenario is very small; entrepreneur prefers crowdfunding to venture capital if the effort cost is low; high threshold and high effort is referred to low threshold and low effort if effort cost is low		
Babich et al (2019)	Successful crowdfunding campaign may not necessarily be beneficial for the firm; projects that may not be beneficial if crowdfunding succeeds are likely to be ones with relatedly low external capital required.		Ryu, Kim and Hahn (2019)
Garrat and Oordt (2019)	ICO is preferred to venture capital for projects with low gross-profit margins; low required amount of capital		
Miglo (2021a)	STO dominate ICO when the extent of moral hazard problems is large; Utility tokens with profit rights (hybrid		Adhami et al (2018)

	tokens) dominate ICO and STO when both moral hazard and demand uncertainty are present		
Chod et al (2021)	Issuing tokens rather than equity mitigates effort under-provision; decentralized governance associated with tokenization eliminates a potential holdup of platform users		

5.2 Moral hazard related to funds diversion

Another issue is that entrepreneur may divert funds raised during crowdfunding campaigns or token issues. Several factors contribute to this phenomenon. One is weakness in bankruptcy laws related to crowdfunding. Secondly, in general by nature of crowdfunding campaign the entrepreneur practically sells the products produced by the firm during crowdfunding, i.e. before the production process even starts so the economic incentive to start production is weakened.

The following model illustrates this point. Consider a firm with an innovative product or service. The firm plans to make an investment I and then sell the product for two periods. The production is $q_t, t = 1,2$. The cost per item equals c. In each period, the demand is $p_t = a - q_t$ If a firm uses crowdfunding, the funders (those who pre-order the product during period 1) expect to receive an extra-benefit (reward) β from the firm. The firm is owned and run by an the entrepreneur that is subject to moral hazard. At the end of period 1, he is able to divert funds received during period 1 (crowdfunding stage). In this case the entrepreneur's profit equals aF, where F is the amount of funds raised during crowdfunding campaign and a is the probability of not beign caught (a parameter that reflects the institutional strength).

Consider period 2. When selecting p_2, the firm maximizes its expected profit, which equals $(p_2 - c)q_2 = (p_2 - c)(a - p_2)$. The solution is:

$$p_2 = \frac{a + c}{2}$$

The firm's expected profit is

$$\frac{(a-c)^2}{4} \tag{13}$$

Without moral hazard problems, in period 1, when selecting p_1, the firm maximizes its expected profit, which equals $(p_1 - c - \beta)q_2 - I = (p_1 - c - \beta)(a - p_2) - I$. The solution is:

$$p_1 = \frac{a + c + \beta}{2}$$

The firm's expected profit is

$$\frac{(a-c-\beta)^2}{4} - I \tag{14}$$

Total amount funds raised during crowdfunding (period 1) equals:

$$F = p_1 q_1 = \frac{a + c + \beta}{2} \frac{a - c - \beta}{2}$$

With moral hazard, the entrepreneur faces the following choice. If he continues with the project, the profit over two periods equals the sum of (13) and (14):

$$\frac{(a-c-\beta)^2}{4} - I + \frac{(a-c)^2}{4} \tag{15}$$

If he diverts funds, the profit equals

$$\alpha F = \alpha \frac{a+c+\beta}{2} \frac{a-c-\beta}{2} \tag{16}$$

If the following holds

$$\frac{(a-c-\beta)^2}{4} - I + \frac{(a-c)^2}{4} < \alpha \frac{a+c+\beta}{2} \frac{a-c-\beta}{2} \tag{17}$$

then (16) is greater than (15), the entrepreneur has an incentive to divert funds. Funders will anticipate it and the campaign can not be successful.

Investment size. The likelihood that (17) holds increases with I. It means that crowdfunding should be preferred if the amount of required investment is relatively small. Strausz (2017) analyzes firm interactions with potential investors using the mechanism design approach. Crowdfunding improves the revelation of information about future demand for the firm products. On the other hand, under crowdfunding there is a moral hazard problem related to potential funds diversion.

Campaign threshold. To explain the point, consider the case with $I = 0$, $\beta = 0$ and $\alpha = 1$. Then (17) holds if $c < a/3$. It demonstrates inefficiency. In an ideal world any project with $c < a$ should be undertaken. But in the second-best world only highly efficient projects may survive. In terms of threshold, if the company sets a threshold below minimal acceptable by the market it will not be accepted. So a minimal threshold is: $F = p_1 q_1 = \frac{a+c}{2}\frac{a-c}{2}$. Note that it is negatively correlated with c implying that high quality firms should have a higher threshold. Minimal acceptable threshold is $\frac{a+a/3}{2}\frac{a-a/3}{2} = \frac{a^2}{3}$. Chemla and Tinn (2019) argue that a larger crowdfunding campaign target mitigates the chance that funds will diverted by the entrepreneur.

Regulation, transparency and the cost of crowdfunding. As follows from (17), if a increases the likelihood that (17) holds increases and it is more likely that crowdfunding should be selected. The same holds if β decreases. Strausz (2017) finds that efficiency is sustainable only if returns exceed investment costs by a significant margin reflecting the degree of moral hazard.

Ellman and Hurkens (2017) provide a simple example of a crowdfunding design that tolerates some fraud risk.

Belavina, Marinesi and Tsoukalas (2020) analyze reward-based crowdfunding by using a model where entrepreneurs have an ability to run away with funders' investments and where product description can be misleading. They show these effects can negatively affect a damage created by each effect separately. The authors consider different mechanisms to mitigate these effects. One of their suggestions consists of forcing the entrepreneurs to stop the campaign once the campaign threshold is reached. Another suggestion, for example, involves escrowing any funds received after the target was reached.

Chod and Lyandres (2021) compare token financing with traditional equity financing. Their analysis includes agency problems. Entrepreneur may not invest cash received during ICO in the production process. Chod and Lyandres (2021) argue that ICO should dominate equity for ventures developing information goods or services, i.e. those for which entrepreneurial effort is crucial, and/or those with relatively low payoff volatility. Among other papers on ICO that assume that entrepreneurs have an ability to divert cash note, for example, Gan, Tsoukalas and Netessine (2021).

Table 5. Moral hazard-based theories (part 2) of crowdfunding and token issues

Paper	Predictions	Direct tests	Indirect evidence
Strausz (2017)	Crowdfunding should be preferred if required investment is smaller than expected profit by a significant margin; Deferred payments should be a part of optimal mechanism		
Ellman and Hurkens (2017)	Actively monitor entrepreneurs to compensate		
Belavina et al (2020)	two deferred-payments mechanisms should be a part of optimal mechanism		
	Firms prefer ICO to IEO if the extent of moral hazard issues is relatively small; IEO will be preferred if the investment size is relatively large, the extent of moral hazard problems faced by the firm is relatively large, and the degree of investors' impatience is relatively small		Khatib (2019) ICO and IEO report (2019)
Chemla and Tinn (2019)	AON dominates KIA in mitigating moral hazard problems; Higher than optimal threshold; many campaigns are overfunded		Mollick (2014), Cumming et al (2019)
Chod and Lyandres (2021)	ICO dominates venture capital (VC) financing when VC investors are under-diversified, when the idiosyncratic component of venture risk is large enough, when the payoff distribution is sufficiently right-skewed, and when the degree of information asymmetry between the entrepreneur and ICO investors is not too large		
Gan et al (2021)	Agency costs of ICO are less important when product margins and demand characteristics improve, and are less severe under equity (rather than utility) token issuance. ICO raise more funds than reward-based crowdfunding, but are better suited for higher-margin products; the percentage of tokens sold is negatively correlated with post-ICO performance		Lyandres, Palazzo and Rabetti (2020)

We have not found any theory specifically related to NFT but as mentioned in Bao and Roubaud (2022) and Chalmers, Fisch, Matthews, Quinn and Recker (2022), a high level of risk related to fraudulent activities by entrepreneurs and respectively moral hazard issues is an important part of NFT agenda and empirical evidence so more research is expected in this area.

6. Behavioural finance-related factors

This section reviews articles that incorporate behavioural finance in their models. One example is entrepreneurial overconfidence (see e.g. Hayward, Shepherd, and Griffin (2006) and Everett and Fairchild (2015)). One idea is that crowdfunding can mitigate inefficiencies due to entrepreneurial bias. The following example proves an illustration (based on Miglo (2021c)).[14] Consider an entrepreneurial firm that plans a crowdfunding campaign and knows the potential demand for its product. Under reward-based crowdfunding the firm should be able to determine an optimal price and quantity produced because the demand is known. Now suppose that the entrepreneur is overconfident and overestimates the demand. In this case the entrepreneur will offer a price which is higher than optimal which will not only reduce the demand but also the firm overall profit. Now consider equity-based crowdfunding. During the sales of shares, a rational entrepreneur (i.e the entrepreneur that is not biased with regard to demand estimation) will expect some amount of cash that should be equal to the amount needed from a rational entrepreneur's point of view in order to produce the optimal quantity of the product. Now suppose that the entrepreneur is overconfident. In this case during the sales of shares he will expect to receive a higher amount of cash. After observing “real” amount, the entrepreneur will realize that the mistake was made in estimating the product demand so he will be able to make some adjustments during production stage compared to his initial thoughts.

Fairchild, Liu, and Yao (2017) analyze a model of a choice between venture capital and crowdfunding. Venture capital provides "network benefits", while crowdfunding-investors demonstrate emotional excitement when using a platform. Also the entrepreneur is overconfident (with regard to benefits of the venture capital network and the level of crowd excitement). Under venture capital financing, there is a moral hazard problem related to the choice of venture capitalist level of effort. (in addition to E's own effort). The firm should weigh

[14] Based on Miglo (2021c).

all of these factors in selecting the best strategy. For example, it is shown that a higher level of overconfidence usually benefits venture capital financing.

Belleflamme, Lambert, and Schwienbacher (2013)[15] compared for-profit and non-profit firms when conducting a crowdfunding campaign. In non-profit firms managers' objective function is different from that of for-profit firms and includes a social factor. They argue that crowdfunding campaigns of nonprofit-based firms are usually more successful than other firms. This is consistent with a more general idea that nonprofit organizations may find it easier to attract money for initiatives that are of interest for the general community due to their reduced focus on profits.

In Belleflamme et al (2014),[16] a firm is facing potential funders with different demand functions. A funder's surplus from buying the product is $v - p$, where p is the price and v is the funder's product valuation. v is uniformly distributed between 0 and a. All backers with v greater than p will buy the product making the demand $q = a - p$. On the spot market, the remaining investors will buy if $v > p_s$, where p_s is the spot price. If $p_s \geq p$, no one will buy on the spot market because it would be optimal to order during crowdfunding. So the crowdfunding model becomes essentially just a spot market model (i.e. there is no special role for crowdfunding). The only way when crowdfunding makes sense is the case $p_s < p$. However this case contradicts the no-arbitrage condition for the equilibrium concept: why would consumers buy for a high price during crowdfunding?! Belleflamme et al (2014) argue that if the objective function of funders is modified and includes additional (eg. social) benefits, the solution changes. Although some researchers support the significance of these benefits (see, for example, Schwartz (2015)), others find that their role seems to be negligeable (see, for example, Cholakova and Clarysse (2015)). Also Belleflamme et al (2014) predict that crowdfunding price should be higher than the spot sale price which is controversial empirically because for most campaigns the opposite is true.

Miglo (2021c) considers a model of the choice between the different types of crowdfunding, which contains elements of the asymmetric information approach and behavioral finance (overconfident entrepreneurs).[17] The paper finds that equity-based

[15]Their model is based on Belleflamme et al (2010).
[16] See also Miglo (2021c).
[17] Lin and Pursiainen (2018) study the importance of overconfidence in experimental setting,

crowdfunding is a more efficient tool of learning the market wisdom for an entrepreneur that is consistent with Arkrot et al (2017).

Table 6. Behavioural finance-based theories of crowdfunding and token issues

Paper	Predictions	Direct tests	Indirect evidence
Fairchild et al (2017)	A higher level of overconfidence usually benefits venture capital financing;	Fairchild et al (2017)	
Belleflamme et al (2013)	Crowdfunding is preferred for small campaigns compared to traditional funding; Non-profit firms can be more successful with crowdfunding than for-profit businesses	Belleflamme et al (2013)	
Belleflamme et al (2014)	Crowdfunding price is higher than spot price		
Miglo (2021c)	Equity-based crowdfunding can be more efficient than reward-based crowdfunding when entrepreneur is overconfident		Arkrot et al (2017), Lin and Pursiainen (2018)

7. Other theories of crowdfunding and token issues

This section provides a review of articles which have not been covered previously. We also comment on other theories in related fields (eg capital structure theory) and discuss their connections to theory of crowdfunding and token issues.

Kumar, Langberg and Zvilichovsky (2019) study the trade-off between price discrimination abilities and cost of financing constraints. They analyze the optimal design of crowdfunding contracts. Greater financing constraints reduce the ability of the firm to extract surplus but may increase production. Kumar et al (2019) show when pre-sale price-discriminating contracts are implementable.

Brown and Davies (2019) analyze a model of crowdfunding where investors can acquire some information about project's quality. The entrepreneur gets a signal by observing

fundraising amounts and then decides whether or not to undertake a risky project. There is a “non-investment threshold” that creates a “loser’s blessing”, i.e. the presence of the threshold encourages contributing without information by reducing the risk of investment in bad projects.

Cong and Xiao (2018) focus on investors’ learning during crowdfunding campaign. They consider AON using a classical model of information cascade. They find that a campaign target plays an important role in imitating preceding agents’ rejections.

Chang (2016) considers a model where backers are assumed to cooperate in deciding whether to invest after observing a common signal about the value of the project. The firm will use crowdfunding in order to cover the difference between the project cost and other sources of funding.

Alaei, Malekian and Mostagir (2016) consider a model of crowdfunding in which funders arrive sequentially and decide whether to invest or not. Funders would prefer not to invest if they think the campaign will not succeed. This can lead to cascades where a campaign fails to reach the threshold even when the product is socially efficient. The paper provides guidelines about how firms should design their campaigns in order to maximize the chances of success. Du, Hu and Wu (2017) also consider a model where backers arrive sequentially at a crowdfunding project. They show that there exists a "cascade effect" on funders' contributions. Du et al (2017) also conduct empirical analysis of their model. According to their data, the majority of projects fail to achieve their goals. They suggest different policies that can be used to mitigate this problem. They argue eg. that the optimal policy has a “cutoff-time” structure, and that the benefit of such policy reaches it’s maximum in the middle of campaigns. Empirical analysis confirms their result.

Li (2018) studies a general contracting problem between investors and firms and the role of profit sharing in collecting the "wisdom of the crowd". It discusses specific implications for the security design and crowdfunding.

Zhang, Savin and Veeraraghavan (2017) develop a model of crowdfunding dynamics that maximizes revenue for a given campaign. They show for example that under the optimal design, the success of campaigns decreases as the goal of a campaign increases, with a more pronounced effect for both very low and very high campaign goals. They also show that campaigns with high goals benefit from highly uncertain environments more than campaigns with low goals.

Hu, Li and Shi (2015) study the optimal product and pricing decisions for AON. When the buyers are sufficiently heterogeneous in their product valuations, the firm should offer different levels of product quality. If the firm uses crowdfunding, the quality gap between products can be reduced.

Lee and Parlour (2019) compare crowdfunding, ICO and traditional bank financing. ICO has a liquidity advantage over crowdfunding since tokens (claims for firm products) can be resold. The paper provides testable implications e.g. it predicts that crowdfunding projects are less profitable than bank financed projects.

Momtaz (2022) suggests a model that analyses pros and cons of ICO or decentralized finance (DeFi) as compared to financing with intermediaries (centralized financing) and argues that DeFi may imply large search frictions and that the presence of intermediaries in blockchain technology can help reducing these frictions.

Miglo (2022) compares crowdfunding and bank financing using learning market demand and moral hazard ideas. The former benefits crowdfunding while the latter benefits bank financing. The paper finds that: large crowdfunding campaigns usually are less efficient in mitigating moral hazard problem than small campaigns; high-profit projects and projects with potentially large markets will tend to select bank financing while largest-size projects should select mixed financing where the firm uses a short crowdfunding campaign and a bank loan.

Among other theories note the following. Myers and Majluf (1984) developed the pecking order theory. Equity is dominated by internal funds and debt in this theory. With regard to crowdfunding we have not found any specific research utilizing similar ideas for example for a choice between equity-based and debt-based crowdfunding. However consistent with this idea, the volume of debt –based crowdfunding exceeds that of equity-based crowdfunding.

Other leading financing theories include the trade-off theory and life cycle theory. Trade-off theory suggests that capital structure reflects a trade-off between the tax benefits of debt and the expected costs of bankruptcy (see eg. Kraus and Litzenberger (1973)). Life cycle theory is based on the idea that firms in the development stage do not have a favorable track record (i.e., credit ratings) of borrowing (Diamond (1991)) and are most likely to be turned down for credit when they need it the most. Mature firms use in general more debt than start-up firms. With regard to crowdfunding it would be interesting to see if similar ideas apply for example for a

choice between equity-based and debt-based crowdfunding.

Harris and Raviv (1988), Aghion and Bolton (1992) and Hart (1995) argue that firms issue debt as a tool of establishing appropriate control structure. With regard to crowdfunding we have not found any specific research utilizing similar ideas for example for a choice between equity-based and other forms of crowdfunding or between STO (that gives control rights to investors) and ICO/IEO.

8. Discussion and Conclusions

Crowdfunding and token issues are among latest innovations in the area of entrepreneurial financing which is a very important area for small businesses, innovative businesses and start-up businesses that constantly face different kinds of problems in this area. In contrast to traditional ways of raising funds these innovations use modern technology much more actively; are usually quicker in reaching potential investors/funders; and use more actively network benefits such as, for example, a large number of interactions between investors/funders and between funders and firms. This article provides a review of the growing number of theoretical papers in the areas of crowdfunding and token issues, compares their findings with empirical evidence and discusses directions for future research.

Theories of crowdfunding and token issues are on the rise but the structure of these fields is still not established clearly. Learning market demand, signaling project quality, using network benefits and mitigating moral hazard problems and behavioural biases seem to be the most popular lines of research. Our analysis shows the following. 1) A significant gap exists between theoretical and empirical articles on crowdfunding and token issues like in no other area of entrepreneurial financing literature. Many of theoretical papers lack empirical support. Furthermore most of them have not been tested directly. Further convergence of theoretical and empirical literature is expected. 2) Theoretical research on debt-based crowdfunding and donation-based crowdfunding is behind that on reward-based crowdfunding and equity-based crowdfunding. So more research is expected in first two mentioned areas especially given that by volume debt-based crowdfunding is the most popular type of crowdfunding.[18] 3) Similarly we find that the number of articles on ICO significantly exceeds that on STO, IEO and NFT. So more research is expected in these areas in near future. 4) Some issues seem to be ambiguous.

[18] See, for example, https://www.statista.com/statistics/946668/global-crowdfunding-volume-worldwide-by-type/

For example, is a higher crowdfunding campaign target an ultimately better signal than a lower campaign target (like in Chakrabotry and Swinney (2021)) or the link between the target size and project quality is not linear (like in Miglo and Miglo (2019))? Also several empirical papers have analyzed the role of asymmetric information in crowdfunding and token issues and possible ways which entrepreneurs can try to mitigate this problem (Kleinert and Volkmann (2019), Fisch and Momtaz, (2020), Kleinert, Volkmann and Grünhagen (2020), Momtaz (2021a)). Momtaz (2021b) suggests that CEO's emotions play an important role in ICO valuations. These findings are interesting but no theoretical papers have them addressed sofar. Also an interesting direction seems to be modelling connections between crowdfunding, bankruptcy and learning from campaign failure. Learning from failure as well as serial entrepreneurship are developing topics in entrepreneurship literature (see, eg. He, Bai and Xiao (2020)). Given that bankruptcy procedures for crowdfunded firms are not very well developed in practice, and given also as we previously discussed that one of the main ideas of crowdfunding for entrepreneurs is learning, it is interesting to see if crowdfunding is an efficient tool of learning from campaign failure (Greenberg and Gerber (2014)). For moral hazard models note the research is dominated by two forms of moral hazard namely entrepreneur's costly effort and possible fund diversion although no explanation exist for why other types of moral hazard have not been explored as well as an approach based on incomplete contracts models that is quite popular in, for example, capital structure models dealing with entrepreneurial firms (eg Aghion and Bolton (1992)).

The limitations of this review includes the focus on the ideas which are mostly similar to the ideas in capital structure area developed in last 40-50 years including asymmetric information, moral hazard problems, behavioural finance etc. Crowdfunding and token issues represent examples of financing strategies for firms that have a lot of new innovative features. So new areas have been included in this review eg. network benefits which are very relevant to both crowdfunding and token issues. Nonetheless one might expect that unlike traditional financing new ideas maybe developed which are not necessarily based on using game theory or contract theory. They have not been a focus of this review. Secondly this review has not been focused on NFT to the same extent as with other types of tokens. On one hand they started to appear historically later than other types of tokens and to the best of my knowledge the research about NFT mostly has empirical papers at the moment. However some of the ideas developed regarding other types of tokens may probably be applied to NFTs as well so it's a good area for future research.

For future research, as was previously mentioned, more research is expected in areas such as incomplete contracts which has a lot of implications in capital structure theory (the closest example is probably Chod et al (2021) that uses a model with a hold-up problem which is probably the closest one to the incomplete contracts literature). Donation-based crowdfunding has been explored seemingly less compared to other types of crowdfunding. Behavioural-based models should be more present (similar to other areas of finance eg. corporate finance where behavioural finance has being playing an important role for last 15-20 years). Also a large gap exists between theoretical models and empirical research. It is a challenging problem to test new theoretical models. Data is often not easily observable especially for entrepreneurial firms and small businesses. In some cases a survey can be used (see eg. Beck, et al. (2006)). The following represent some interesting examples. Belleflamme et al (2013) developed a model of crowdfunding for non-profit firms and then tested it. Similarly Chemla and Tinn (2017) developed a model of crowdfunding based on moral hazard and presented some data consistent with their model. Also it is worth mentioning Lyandres et al (2020) that provide some testing of results in Gan et al (2021).

In addition note that an interesting/important issue is the implementation of theoretical models in practice. Similarly to traditional financing (capital structure) literature most practical tests of theories are based on indirect confirmation of data consistency with models predictions rather than checking that developed models are directly applied by existing entreprises. This is an interesting direction for future research. More case studies, more surveys related to theoretical models and also related to the attitude of entrepreneurs regarding these theories is expected (similar to Graham and Harvey (2001) survey of managers regarding theoretical concepts in corporate finance). The usage of specific models/theories in practice also depends on the structure/content of educational program related to crowdfunding/token issues. These are relatively new topics for most programs so a time gap is expected before one can see some results here. Note though that several papers provide examples of firms/industries that seem to be (indirectly) consistent with suggested models. Note for example Chemla and Tinn (2018) with regard to technology firms; Chen, Gal-Or and Roma (2018) with regard to such firms as Scanadu, Formlabs etc.; Li and Mann (2018) with regard to Filecoin etc.

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