Choice Between IEO and ICO: Speed vs. Liquidity vs. Risk

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Abstract

This paper analyzes a financing problem for an innovative firm that is considering launching a web-based platform. Our model is the first one that analyzes an entrepreneur's choice between initial exchange offering (IEO) and initial coin offering (ICO). Compared to ICO, under IEO the firm is subject to screening by an exchange that reduces the risk of investment in tokens; also the firm gets access to a larger set of potential investors; finally tokens become listed on an exchange faster. We argue that IEO is a better option for the firm if: 1) the investment size is relatively large; 2) the extent of moral hazard problems faced by the firm is relatively large; 3) the degree of investors' impatience is relatively small. We aslo find a non-linear relationship between firm quality and its financing choice. Most of these predictions are new and have not been tested sofar.

Keywords: FinTech; Entrepreneurial Finance; Initial Coin Offering; Initial Exchange Offering; Moral Hazard; Utility Tokens; Listing

JEL Codes: D82, G32, L11, L26, M13

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1 Introduction

Financing strategy is a crucial factor of success for innovative businesses (Wilson (2015)). It is not surprising that these firms use a variety of different strategies to fund their projects including private equity, business incubators, venture capital finance, angel finance, seed accelerators, crowdfunding and most recently initial coin offerings (ICOs) and initial exchange offerings (IEOs). Usually under ICO, a firm sells utility tokens which give their buyers (investors) the right to use the company's future products or services. Under IEO, a company sells tokens using the service of organized exchange for cryptocurrencies such as Binance, LBANK and Coinbene.[1] The exchange is directly involved in the selection of projects, organization and sale of tokens and becomes the key marketing partner of the project. IEOs had strong momentum in 2019 with largest Bitfinex IEO raising $US1 bln.[2]

IEO is designed to minimize risks, liquidity problems and a delay in listing tokens at the end of the token sale. A cryptocurrency exchange distributes digital assets among interested investors who are users of the trading platform. Compared to ICO, in the case of IEO: 1) the fraud risk for investors is lower. The project is launched at the exchange after serious verification. The exchange rejects a suspisous/low quality project to maintain its reputation; 2) listing of new tokens is faster; 3) the investment process is technically more simple for investors; 4) the marketing costs for the project team are reduced because the organizers can reach a large number of exchange users; 5) IEO increases the effectiveness of token promotion on the market. At the same time, all these advantages have some drawbacks. The main one is the price for the IEO.[3]

ICO and IEO research is quickly growing. Most papers are focused on ICOs. Theoretical papers on ICOs include, amomg others, Catalini and Gans (2018), Li and Mann (2018), Govindan and Wilson (2009), Bakos and Ha laburda (2018), Cong and Wang (2018), Lee and Parlour (2018), Garratt and van Oordt (2019) and Miglo (2019, 2020).[4] Research on IEOs is in its early stages and as we are writing this article it includes several empirical papers (eg. Myalo (2019)) but no theoretical paper to the best of

[1] Myalo (2019).

[2] ICO and IEO report (2020).

[3] See Beedham (2019) or Myalo (2019) for more details.

[4] For empirical research on ICO see, for example, Adhami, Giudici and Martinazzi (2018), Amsden and Schweizer (2018) and Ante, Sandner and Fiedler (2018).

our knowledge. Respectively no paper is focused on the choice between ICO and IEO. For many entrepreneurs this issue seems to be very important.[5] In this article we shed some light on these unexplored questions namely what are economic ideas behind using IEO compared to ICO and how firms select between different types of financing.

In our model an entrepreneur with an innovative idea considers launching a web-based platform. In order to finance the development of the platform, the entrepreneur can use ICO or IEO. There are two types of investors. Type 1 are interested in using tokens to purchase firm products in the future. Type 2 are interested in reselling tokens and creating capital gain. The number of type 1 investors is crucial because it highlights the market demand for firm products. We first consider the case without moral hazard and promoting effects of early listing under IEO. In this case, the choice of financing method is irrelevant because both methods lead to the same result for the firm. The reason is that in either case the number of type 1 investors is crucial and nothing would change it unless other factors/market imperfections are considered. We then consider our main case when, under IEO, there is promotional effect of listing. Also under ICO the entrepreneur is subject to moral hazard problems, ie. he can be involved in an inefficient project ("steeling" funds from investors). Our analysis show that IEO will be preffered if the company size is relatively large, the number of type 1 investors is relatively small and if exchange fees for IEO are relatively low.

Most of our model predictions have not been tested sofar. Interestingly though, one of our main predictions namely that likelihood of selecting IEO is positively related to project size seems to be consistent with recent data. For example 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).

The model also predicts that companies for which moral hazard problems is an issue, should prefer IEO. “... I feel that IEO will be the best way for entrepreneurs to fundraise and take they projects forward. Exchanges guarantee that due diligence have been done and that someone has checked the boxes for you. For Memob’s blockchain, we decided that the best way to take forward this revolutionary approach was to have an IEO,” Alexandre Hawari, CEO, Memob, told AMEinfo.[6]

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

[6] Khatib (2019).

The rest of the paper is organized as follows. Section 2 describes the basic model and some preliminary results. Section 3 provides an analysis for the model with moral hazard and other factors. Section 4 analyzes the consistency of the model's predictions with observed empirical evidence. Section 5 discusses the model's robustness and its potential extensions and Section 6 is a conclusion to the study.

2 The Model Description and Some Preliminaries

An innovative firm has monopoly power over its idea of creating a website platform for selling a product/service. The initial fixed cost of the project is I.[7] The variable cost of production of one unit of the product is c. To finance the development of the product the firm can use ICO (initial coin offering) or IEO (initial exchange offering). In both cases, the firm sells utility tokens. Compared to ICO, under IEO: 1) the firm is screened by an exchange that reduces the risk of low-quality campaigns including entrepreneurial fraud;[8] 2) the firm gets access to a larger set of potential investors; 3) tokens become listed on an exchange faster (see Myalo (2019)). More specifically, we model these differences as follows. There are 3 periods in the model. In period 0, tokens are sold for the price p_0. In period 1 under IEO tokens become listed and can be sold on an exchange. In period 2 the firm produces products and tokens can be used to buy products and services offered by the firm and they can be sold on an exchange under both IEO and ICO. There are two types of investors. Type 1 are only interested in products offered by the firm (each investor is interested in consuming one unit of the product). Total number of type 1 investors is $\overline{n_1}$. Type 2 are interested in selling tokens and receiving capital gains. The total number of type 2 investors is unlimited. After the initial issue of tokens in period 0, token market participants receive inofrmation about token market future prospects. After that a fraction γ of randomly chosen type 2 investors who purchased tokens during IEO will sell them in period 1 and the remaining type 2 investors will sell their tokens in period 2. γ is related to token market uncertainty. It is well

[7] In Section 5 we discuss the model's assumptions.

[8] A lot of campaigns fail or turn out to be low quality or even fraud in some cases. See, for example, Cumming, Johan and Pant (2019), OECD (2019).

known from the literature that the degree of this uncertainty is very high (see eg Antonakakis, Chatziantoniou and Gabauer (2019) or Financial Stability Board (2018)). In addition to factors affecting the markets for traditional financial assets, token market is also affected by factors affecting blockchain technology development, cryptocurrencies (since payments can be made in cryptotokens) etc. High γ is associated with token market uncertainty and investors impatience, while low γ means that token market anticipations are rather positive and investors are patient. The consumption value of tokens is v. All investors are risk-neutral and risk-free interest rate is 0. So investors purchase tokens if the expected payoff covers investment cost. Also, the entrepreneur is subject to moral hazard. Under ICO, after funds are collected, the entrepreneur can be involved in some inefficient project instead of continuing with production. More specifically we assume that in the case of success this "inefficient" project brings an amount of profit equal to the amount of funds collected during ICO and in the case of failure it gives the entrepreneur zero. The probability of success is δ. An interpretation is that funds are stolen and $1-\delta$ is the probability of being caught. Finally, under IEO, the firm pays a fee F to the exchange. Also information about all issues of tokens is imperfect. More specfically we assume that since under IEO more investors are potentially reached than under ICO and also because under IEO the tokens are listed on an exchange faster, IEO has a promotional effect i.e under IEO some investors get information about new firm and its tokens even though they did not have it otherwise. In the model, an additional number X of type 1 investors are created in case of IEO in period 2. Finally if the number of tokens is smaller than the total number of potential investors when the firm sells tokens in period 0 we assume that type 1 investors will buy first in case of ICO and type 2 investors will buy first in case of IEO.[9]

Let n be the total number of tokens issued and n_j be the number of type j investors, $j = 1, 2$.

$$n_1 \leq \overline{n_1}$$

$$n = n_1 + n_2$$

The value of issued tokens should cover the investment cost and production

[9]This assumption is not crucial for our paper result qualitatively and is consistent with the spirit of different types of financing. ICO is more closed compared to IEO so ICO is less attractive for type 2 investors compared to type 1 investors while IEO is more attractive for them. More discussion is provided in Section 5.

cost:

$$np_0 \geq I + cn \tag{1}$$

First consider perfect information scenarios without moral hazard problems and other market imperfections eg. exchange fees, i.e. $X = 0$, $F = 0$ and $\delta = 1$.

2.1 ICO

The timing of events is present in Figure 1.

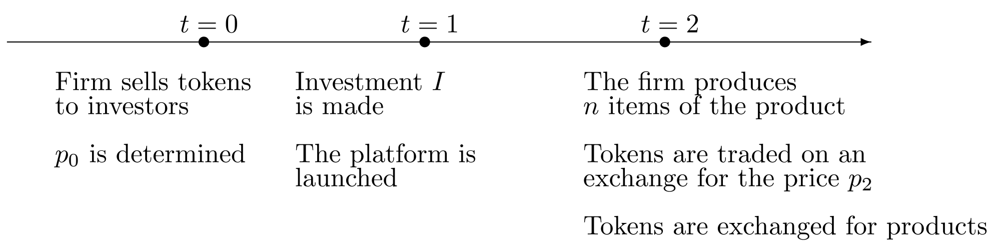

Figure 1. The sequence of events for ICO.

First note that with probability γ the return for type 2 investors participating in an ICO is zero because they will not be able to sell tokens in period 1 (tokens will not be listed in case of ICO until period 2).

Equilibrium in token market in period 2 depends on the total number of token buyers and sellers. If the number of token buyers is equal or greater than the number of token sellers, equilibrium price is v (see Figure 2a).

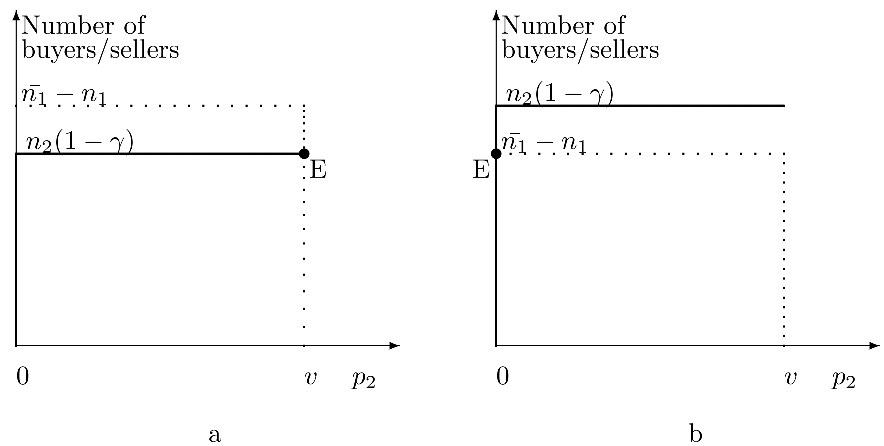

Figure 2. Token market equilibrium (E). Bold line: token supply; doted line-token demand. a) the number of token buyers is equal or greater than the number of token sellers; b) the number of token buyers is smaller than the number of token sellers.

Otherwise the price is 0 (see Figure 2b). Indeed in the latter case if the price is greater than zero, it can not be an equilibrium because any of sellers who did not sell his tokens could offer a slightly lower price.

In our case the number of token sellers in period 2 is $n_2(1-\gamma)$ and the number of buyers equals $\overline{n_1} - n_1$. So if

$$\overline{n_1} - n_1 \geq n_2(1-\gamma) \tag{2}$$

then $p_2 = v$. Otherwise $p_2 = 0$. In fact, (2) always holds. Indeed if it does not and $p_2 = 0$, type 2 investors will not be interested in purchasing tokens and $n_2 = 0$ implying that (2) holds.

Also one should have:

$$p_0 \leq v$$

The firm selects p_0 and n to maximize its profit:

$$\Pi = np_0 - I - cn$$

The solution is as follows. If $v \leq I/\overline{n_1} + c$, optimal $n = 0$. Otherwise two strategies are possible. First is

$$p_0 = v$$

In this case type 2 investors are not interested to buy tokens during ICO because their expected payoff ($(1-\gamma)v$) is less than p_0. It implies

$$n = \overline{n_1}$$

$$\Pi = \overline{n_1}v - I - c\overline{n_1} \tag{3}$$

Second is

$$p_0 = (1-\gamma)v$$

Eventhough type 2 investors are interested in purchasing tokens during ICO, the total number of issued tokens can not exceed $\overline{n_1}$ becasue type 2 investors will still resell their tokens to type 1 investors and since one consumer is only interested in consuming one good, the total number of produced goods can not be larger than $\overline{n_1}$.

$$n = \overline{n_1}$$

$$\Pi = \overline{n_1}v(1-\gamma) - I - c\overline{n_1} \tag{4}$$

First strategy is optimal.

2.2 IEO

The timing of events is present in Figure 3.

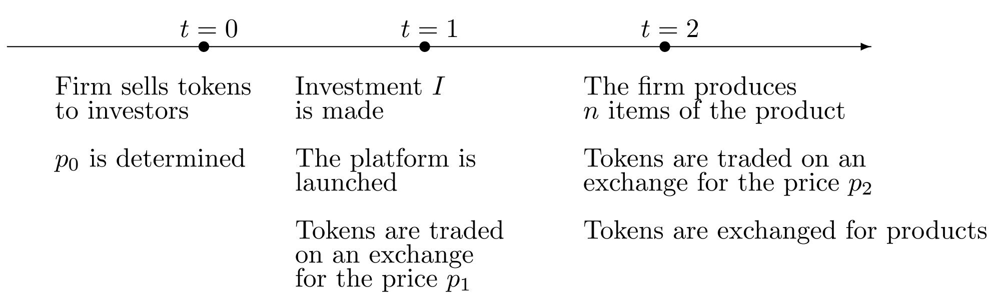

Figure 3. The sequence of events for IEO.

Consider token market equilibrium in period 1. The number of token sellers in period 1 is γn_2 and the number of buyers equals $\overline{n_1} - n_1$. So if

$$\overline{n_1} - n_1 \geq \gamma n_2 \tag{5}$$

then $p_1 = v$. Otherwise $p_1 = 0$. Suppose (5) holds. In this case $n_{11} = \gamma n_2$ (n_{11} is the number of type 1 investors who purchased tokens in period 1).

Consider token market equilibrium in period 2. The number of token sellers in period 2 is $n_2(1-\gamma)$ and the number of buyers equals $\overline{n_1} - n_1 - \gamma n_2$. So if

$$\overline{n_1} - n_1 - \gamma n_2 \geq n_2(1-\gamma)$$

or

$$\overline{n_1} \geq n_1 + n_2 \tag{6}$$

then $p_2 = v$. Otherwise $p_2 = 0$. Two cases are possible.

1. Suppose that condition (6) holds. The firm maximizes its profit:

$$\Pi = np_0 - I - cn$$

The solution is as follows. *If* $v \leq I/\overline{n_1} + c$, optimal $n = 0$. The project is worthless. Otherwise the solution is

$$p_0 = v$$

$$n = \overline{n_1}$$

$$\Pi = \overline{n_1}v - I - c\overline{n_1} \tag{7}$$

2. Suppose that (6) does not hold. Then

$$\overline{n_1} < n_1 + n_2 \tag{8}$$

and $p_2 = 0$. Also

$$p_0 \leq v$$

Otherwise no investor is interested in purchasing tokens. The solution is as follows. If $v \leq I/\overline{n_1} + c$, optimal $n = 0$ and $q = 0$. The project is worthless. Otherwise two strategies are possible. First is $p_0 = v$. In this case type 2 investors are not interested to buy tokens during ICO because their expected payoff (γv) is less than p_0 that contradicts (8). But this contradicys our assumption that (6) does not hold. Another strategy is[10]

$$p_0 = \gamma v$$

Even though type 2 investors are interested in purchasing tokens during ICO, the total number of issued tokens can not exceed $\overline{n_1}$ becasue type 2 investors will still resell their tokens to type 1 investors and since one consumer is only interested in consuming one good, the total number of produced goods can not be larger than $\overline{n_1}$.

$$n = \overline{n_1}$$

$$\Pi = v\gamma\overline{n_1} - I - c\overline{n_1}$$

First strategy is optimal.

Now suppose (5) does not hold. In this case $n_{11} = \overline{n_1} - n_1$.

Consider token market equilibrium in period 2. The number of token sellers in period 2 is $n_2(1-\gamma)$ and the number of buyers equals 0. So $p_2 = 0$. No type 2 investors will buy tokens initially since their payoff is 0. But this contradicts that (5) does not hold.

Lemma 1. *Without moral hazard and absence of promoting effect of listing, there are two cases: 1) if $v \leq I/\overline{n_1} + c$, the project is worthless for the entrepreneur; 2) otherwise the firm is indifferent between ICO and IEO.*

Proof. Follows from the analysis of (3) and (7).

This result is not surprising given that in the absence of any financial market imperfections every type of financing should have the same result (similar to Modigliani-Miller proposition (1958)).

3 Moral hazard and promoting effect of early listing

In this section we analyze the role of moral hazard, promotional effect of IEO and other factors on the firm's choice of financing strategy. Different strategies attract different types of investors. Also the firm choice affects the incentives of the entrepreneur.

[10] Any price below v but higher than γv makes no sense for the firm because it reduces firm profit without attracting new token buyers.

3.1 ICO

The timing of events for ICO is present in Figure 4.

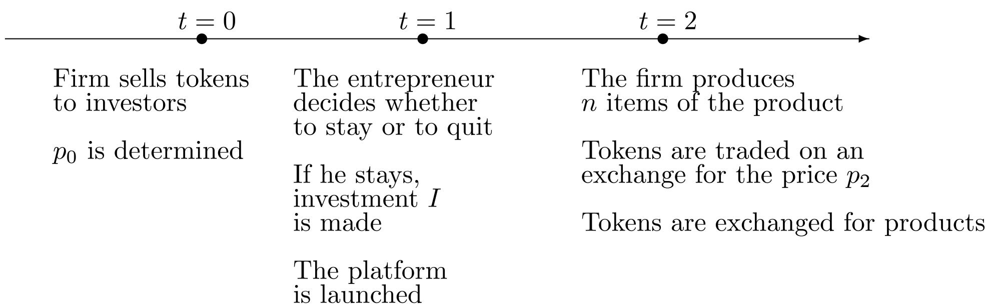

Figure 4. The sequence of events for ICO.

Difference with previous case is that now we should consider the entrepreneur's decision whether to "steel" money from the firm.

If $p_0 = v$ and the entrepreneur continues, his payoff equals $\overline{n_1}v - I - c\overline{n_1}$ according to (3). If he withdraws funds then it is $(1 - \delta)\overline{n_1}v$. If

$$\delta > \frac{I + c\overline{n_1}}{\overline{n_1}v} \tag{9}$$

then he continues. Note that RHS (right-hand side) of (9) is less than 1 because of (1).

Funders rationally anticipate opportunity for steeling and will not provide funds if condition (9) does not hold.

Note that lowering ICO token price does not increase firm credibility in the eyes of investors. Indeed suppose $p_0 = v(1 - \gamma)$. If the entrepreneur continues, his payoff equals $\overline{n_1}v(1 - \gamma) - I - c\overline{n_1}$ according to (4). If he withdraws funds then it is $(1 - \delta)\overline{n_1}v(1 - \gamma)$. If

$$\delta > \frac{I + c\overline{n_1}}{\overline{n_1}v(1 - \gamma)} \tag{10}$$

then he continues. RHS of (10) is greater than RHS of (9) so if (10) does not hold (i.e. the entrepreneur steels money when the price equals v), (10) does hold too and the entrepreneur steels money even if the price is lower. This leads to the following proposition.

Proposition 1. *If* $\delta > \frac{I + c\overline{n_1}}{\overline{n_1} v}$, $n = \overline{n_1}$ *and* $\Pi = \overline{n_1} v - I - c\overline{n_1}$. *If* $\delta < \frac{I + c\overline{n_1}}{\overline{n_1} v}$, *ICO is not feasible.*

Proof. Follows from above.

3.2 IEO

The timing of events for IEO is present in Figure 5.

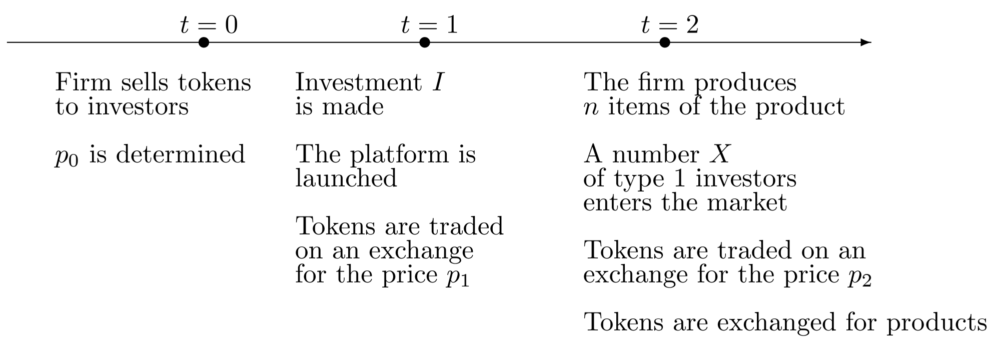

Figure 5. The sequence of events with moral hazard for IEO.

The cost of the project does now include an exchange fee F that implies:

$$np_0 \geq I + cn + F$$

The firm maximizes its profit:

$$\Pi = np_0 - I - cn - F \tag{11}$$

The number of sellers in period 1 is γn_2 and the number of buyers equals $\overline{n_1} - n_1$. Two cases are possible.

If

$$\overline{n_1} - n_1 \geq \gamma n_2 \tag{12}$$

then $p_1 = v$. The number of sellers in period 2 is $(1-\gamma)n_2$ and the number of buyers equals $\overline{n_1} - n_1 - n_{12} + X$, where n_{12} is the number of type 1 investors who purchased tokens in period 1 from type 2 investors. Since (12) holds, $n_{12} = \gamma n_2$. So if

$$\overline{n_1} - n_1 - \gamma n_2 + X \geq (1 - \gamma)n_2 \tag{13}$$

or

$$\overline{n_1} + X \geq n_1 + n_2$$

then $p_2 = v$. Otherwise $p_2 = 0$.

If

$$\overline{n_1} - n_1 < \gamma n_2 \tag{14}$$

then $p_1 = 0$. The number of sellers in period 2 is $(1-\gamma)n_2$ and the number of buyers equals $\overline{n_1} - n_1 - n_{12} + X$, where n_{12} is the number of type 1 investors who purchased tokens in period 1 from type 2 investors. Since (12) does not hold, $n_{12} = \overline{n_1} - n_1$. So the number of buyers in period 2 is X. If

$$X \geq (1 - \gamma)n_2 \tag{15}$$

then $p_2 = v$. Otherwise $p_2 = 0$. In the latter case type 2 investors are not interested in purchasing tokens during IEO, i.e. $n_2 = 0$ leading to a contradiction with (14). So if (14) holds, (15) should hold too.

Suppose (12) holds. Two situations are possible.

1) (13) holds. When both constraints hold, $p_0 = v$ as was noted previously, and, as follows from (11), the solution for the firm is to find maximal n such that both constraints (12) and (13) hold. Type 2 investors are interested in buying tokens during IEO because both constraints hold, $p_1 = p_2 = v$, the expected payoff to type 2 investor equals v and it covers the investment cost. It implies that no type 1 investor will be able to buy a token in period 0: $n_1 = 0$. Condition (12) becomes

$$\overline{n_1} \geq \gamma n \tag{16}$$

and condition (13) becomes

$$\overline{n_1} + X \geq n \tag{17}$$

Two cases are possible

If

$$\overline{n_1} + X \geq \frac{\overline{n_1}}{\gamma}$$

the maximal n that satisfy both (16) and (17) is

$$n = \overline{n_1}/\gamma$$

If

$$\overline{n_1} + X < \frac{\overline{n_1}}{\gamma}$$

the solution is

$$n = \overline{n_1} + X$$

2) (13) does not hold. Two strategies are possible for the firm. First $p_0 = v$. In this case type 2 investors will not buy tokens. This leads to a contradiction that (13) does not hold. Another strategy is $p_0 = \gamma v$. If $\overline{n_1} + X \geq \frac{\overline{n_1}}{\gamma}$, no n exists that simultaneously satisfies (16) and does not satisfy (17). If $\overline{n_1} + X < \frac{\overline{n_1}}{\gamma}$ the maximal n that satisfy (16) and does not satisfy (17) is

$$n = \overline{n_1}/\gamma$$

Now suppose (12) does not hold. If (13) does not hold, then $p_2 = 0$. In this case no type 2 investor would buy tokens leading to a contradiction that (12) does not hold. So (13) holds. Two strategies are possible for the firm. First $p_0 = v$. In this case type 2 investors will not buy tokens. This leads to a contradiction that (12) does not hold. Another strategy is $p_0 = (1-\gamma)v$. Since type 2 investors are interested in buying tokens, type 1 investors will be able to purchase tokens during IEO: $n_1 = 0$. Condition (12) becomes $\overline{n_1} \geq \gamma n$ and condition (15) becomes $X \geq (1-\gamma)n_2$. Two cases are possible. If $\overline{n_1} + X \geq \frac{\overline{n_1}}{\gamma}$, the solution is

$$n = \frac{X}{1-\gamma}$$

If $\overline{n_1} + X < \frac{\overline{n_1}}{\gamma}$, no solution exists.

Proposition 2. *1) If* $X < \frac{\overline{n_1}(1-\gamma)}{\gamma}$, $n = \overline{n_1} + X$ *and* $\Pi = (\overline{n_1} + X)v - I - c(\overline{n_1} + X) - F$. *2) If* $X > \frac{\overline{n_1}(1-\gamma)}{\gamma}$ *then if*

$$\frac{(1-\gamma)(v-c)}{\gamma((1-\gamma)v-c)} \geq \frac{X}{\overline{n_1}} \tag{18}$$

$n = \overline{n_1}/\gamma$ *and* $\Pi = v\overline{n_1}/\gamma - I - c\overline{n_1}/\gamma - F$. *Otheriwse* $n = X/(1-\gamma)$ and $\Pi = Xv - I - cX/(1-\gamma) - F$.

Proof. Consider $X < \frac{\overline{n_1}(1-\gamma)}{\gamma}$. Two strategies are possible. if $p_0 = v$ then $n = \overline{n_1} + X$ and $\Pi = (\overline{n_1} + X)v - I - c(\overline{n_1} + X) - F$. If $p_0 = \gamma v$ then $n = \overline{n_1}/\gamma$ and $\Pi = \overline{n_1}v - I - c\overline{n_1}/\gamma - F$ which is smaller than previous result.

Consider $X > \frac{\overline{n_1}(1-\gamma)}{\gamma}$. Two strategies are possible. if $p_0 = v$ then $n = \overline{n_1}/\gamma$ *and* $\Pi = v\overline{n_1}/\gamma - I - c\overline{n_1}/\gamma - F$. if $p = (1-\gamma)v$ then $n = \frac{X}{1-\gamma}$ and $\Pi = Xv - I - c\frac{X}{1-\gamma} - F$. Comparing these two results leads to the following. If $\frac{(1-\gamma)(v-c)}{\gamma((1-\gamma)v-c)} \geq \frac{X}{\overline{n_1}}$ then the former is greater and vice versa.

The interpretation of these results is as follows. If X is low, the firm will be able to sell tokens equal to the number of all type 1 investors (existing ones ($\overline{n_1}$) and expected ones in the future (X)). When X increases, a firm is not always able to sell an increasing number of tokens in period 0 in anticipation of future high demand from type 1 investors because of risk that too many tokens will be offered for sale in period 1 or 2 leading to low market price of token. In order to keep the incentive of type 2 investors to particpate in token issue the firm would then need to consider opportunities for lowering the initial price of tokens. So different scenarios are possible. For example, if the number of existing type 1 investors is relatively high (condition (18)) compared to expected future demand, the firm would prefer to keep the issue price high while otherwise it may consider lowering the issue price.

Now we compare ICO and IEO.

Proposition 3. *1) If* $\delta < \frac{I + c\overline{n_1}}{\overline{n_1}v}$*, IEO is preferred. (ICO is not feasible); 2) If* $\delta > \frac{I + c\overline{n_1}}{\overline{n_1}v}$ *then: if* $X < \frac{\overline{n_1}(1-\gamma)}{\gamma}$*, IEO is preferred if* $X(v-c) > F$*. If* $X > \frac{\overline{n_1}(1-\gamma)}{\gamma}$ and $\frac{(1-\gamma)(v-c)}{\gamma((1-\gamma)v-c)} \geq \frac{X}{\overline{n_1}}$*, IEO is preferred. If* $X > \frac{\overline{n_1}(1-\gamma)}{\gamma}$ and $\frac{(1-\gamma)(v-c)}{\gamma((1-\gamma)v-c)} < \frac{X}{\overline{n_1}}$*, IEO is preferred if* $v(X - \overline{n_1}) - c(\frac{X}{1-\gamma} - \overline{n_1}) > F$.

Proof. Two cases are possible.

1. If

$$\delta < \frac{I + c\overline{n_1}}{\overline{n_1}v} \tag{19}$$

IEO is preferred (ICO is not feasible according to Proposition 1).

2. $\frac{I + c\overline{n_1}}{\overline{n_1}v} < \delta$. *if* $X < \frac{\overline{n_1}(1-\gamma)}{\gamma}$ then if IEO*:* $n = \overline{n_1} + X$ and $\Pi = (\overline{n_1} + X)v - I - c(\overline{n_1} + X) - F$. If ICO then $\Pi = \overline{n_1}v - I - c\overline{n_1}$. IEO is preferred if

$$X(v-c) > F \tag{20}$$

If $X > \frac{\overline{n_1}(1-\gamma)}{\gamma}$ and $\frac{v-c}{v-c/(1-\gamma)} \geq \frac{X\gamma}{\overline{n_1}}$, then if IEO: $n = \overline{n_1}/\gamma$ and $\Pi = v\overline{n_1}/\gamma - I - c\overline{n_1}/\gamma - F$. If ICO then $\Pi = \overline{n_1}v - I - c\overline{n_1}$. IEO is preferred.

If $X > \frac{\overline{n_1}(1-\gamma)}{\gamma}$ and $\frac{v-c}{v-c/(1-\gamma)} < \frac{X\gamma}{\overline{n_1}}$, then if IEO: $n = X/(1-\gamma)$ and $\Pi = Xv - I - cX/(1-\gamma) - F$. If ICO then $\Pi = \overline{n_1}v - I - c\overline{n_1}$. IEO is preferred if

$$v(X - \overline{n_1}) - c(\frac{X}{1-\gamma} - \overline{n_1}) > F \tag{21}$$

4 Implications

Our paper has several implications for an entrepreneurial firm's choice of financing strategy.

Proposition 3 implies that IEO is preferred to ICO if the investment cost of the project increases. Indeed, (19) is more likely to hold when I increases and vice versa. If (19) holds, then ICO is not feasible and IEO is the dominant choice for entrepreneurs. Although this prediction has not been tested directly it is consistent with the spirit of, for example, Khatib (2019). The author finds 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).

Proposition 3 also implies that the likelihood of IEO is negatively related to γ. Indeed the derivative of LHS of (21) equals $-\frac{cX}{(1-\gamma)^2} < 0$. It means that IEO is better than ICO when the token market participants do not anticipate long-term problems and/or short-term speculation (high volume of token sales in the short run). In the case of IEO it is better to put this kind of pressure on later periods when the promotional effect of IEO will have an impact on a number of potential token buyers and the market pressure coming from token sale by type 2 investors is mitigated.

Also the model predicts that under IEO one can have a situation when the price of tokens increases by more than under ICO but not an opposite scenario. Indeed if (21) holds then under IEO $p_0 = (1-\gamma)v$ and $p_2 = v$ which means that under IEO the extent of underpricing (low token issue price) is larger than under ICO but on the other hand a long-term return on tokens is higher.

Finally the model predicts that the likelihood of IEO is negatively related to the size of exchange fees (F) and the probability of "inefficient project" (δ) success and positively related to the expected increase in the demand from type 1 of investors due to promotional effect of early listing (X).

Also the model predicts a non-linear relationship between product quality

(v) and firm choice. First when v is too low condition (9) will not hold implying that IEO will be selected. When v increases and (9) holds then based on conditions (20) and (21), ICO can be preferred if v is not too high ("intermediate range") and vice versa. So when v is very large, IEO is preferred choice again.

5 The Model Extensions And Robustness

Other types of moral hazard. In our model, the moral hazard takes place because the production process is costly for the entrepreneur and he will fully bear this cost while the expected reward in case of quitting may be higher if δ is sufficiently low. To some extent this approach is similar to the asset substituion effect in financing literature when entrepreneur switches to a socially inefficient project when he is not going to fully enjoy the benefits of socially efficient project because of payoff structure (Jensen and Meckling (1976)). There are many different ways to analyze moral hazard issues, for example, to explicitely assume that the entrepreneurs can issue security token[11] in additon to utility tokens and then assume that his effort can be socially inefficient because of agency cost of equity. One can also include the cryptocurrency exchange moral hazard problem when conducting a project expertise etc. At this point, however, we do not see which parts of our model results can be affected qualitatively without significantly complicating the model's solutions so we leave it for future research.

Mixed financing and more types of financing. Unlike capital structure literature, where a debt/equity mix is a very common strategy (as opposed to pure equity or pure debt financing),[12] simultaneously using ICO and IEO has not shown to be common so we dont consider it in the model. One can aslo include other types of tokens (such as mentioned previously security tokens) or other types of financing (such as bank loans or venture capital). There exists a large spectrum of opportunities here and future evidence would demonstrate which cases are really important for entrepreneurs and which ones deserve to be investigated further. At this point we can see that the choice

[11] See, for example, Adhami, Giudici and Martinazzi (2017), Ante and Fiedler (2019) and Miglo (2019).

[12] For a review of capital structure literature see, among others, Harris and Raviv (1991) or Miglo (2011). For a traditional analysis of the capital structure of internet companies see, for example, Miglo, Lee and Liang (2014).

between ICO and IEO is a real issue for many innovative entrepreneurs[13] so we focus on this case.

Two stages. One can assume that the firm issues tokens in two stages. As far as we can see, the results will not change with the introduction of this assumption however if one introduces for example two development periods in the model with two different stages of investment in each period the results will change at least quantitatively. It is hard to predict the consequences of such a change so it is difficult to judge if it is a promising avenue for future research.

Different priority rules. In the model we assumed that when the number of tokens is smaller when the number of investors then under ICO type 1 investors will buy first and under IEO type 2 investors will buy first. As we mentioned, this assumption is not important qualitatively for the model results. One can further extend the model by assuming, for example, that under IEO a fraction α of tokens is purchased by type 1 investors and repsectively $1-\alpha$ by type 1 investors. $1-\alpha$ is related to the overall level of market investors reach by an exchange. Our analysis shows that no result of our analysis changes qualitatively althouhg some formulas would change. For example, condition (21) becomes $v(\frac{X}{1-\alpha}-\overline{n_1})-c(\frac{X}{(1-\gamma)(1-\alpha)}-\overline{n_1})>F$. If it holds, the firm would prefer IEO and vice versa. All predictions remain the same with an addition of a new prediction about the role of changes in α. The derivative of LHS in α of this condition equals $v(1-\gamma)-c$. If γ is relatively small, it is positive and higher a improves the attractiveness of IEO and vice versa.

Asymmetric information. In our paper we focus on ex-post asymmetric information, i.e an environment where the outcome of a financing strategy depends on the incentives of the entrepreneur. One can consider a model with ex-ante asymmetric information where the entrepreneur initially has some signals about its platform and would like to signal it to the market via tokens issue. It is an interesting avenue for future analysis but it is beyond the scope of our model.

6 Conclusions

This article is the first one that offers a model of the choice between ICO and IEO for an innovative firm looking to fund the development of its platform.

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

Existing literature usually focuses on ICOs. Our paper is also the first one that has a theoretical model of IEO. The topic is a highly growing area among researchers and practioners. Our model is based on some important features of IEO. As compared to ICO, under IEO the firm is subject to screening by a cryptocurrency exchange; also the firm gets access to a larger set of potential investors; finally tokens become listed on an exchange faster. We argue that IEO is a better option for the firm if: 1) the investment size is relatively large; 2) the extent of moral hazard problems faced by the firm is relatively large; 3) the token market prospects are relatively positive and the degree of investors' impatience is relatively small. We also find a non-linear relationship between firm quality and its financing choice. Most of our model's predictions are new and have not yet been tested but they seem to be consistent to some extent with some recent publications on IEO.[14]

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[14] See eg. Khatib (2019) and ICO and IEO report (2019).

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