Regulation of Initial Coin Offerings

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Abstract

We analyze the regulation of initial coin offerings (ICOs), in which a company raises funds by pre-selling access to a later product or service. We start by presenting a model that rationalizes the use of ICOs for launching peer-to-peer platforms: by adding dynamics to a platform launch, ICOs can 1) solve a coordination failure problem inherent in many projects with network effects (strategic complementarity in consumers’ participation); and 2) harness the “wisdom of the crowd” by aggregating dispersed signals about project quality. Through either mechanism, an ICO increases platform value, makes the launch of a valuable platform more likely, and enhances social welfare. However, the dynamics of ICOs are also subject to manipulation without strong enforcement on disclosures of off-chain compensation. We use our model to analyze under what circumstances ICOs should be banned or allowed, and highlight the importance of the disclosure requirement.

Keywords: coordination/global game, ICO, FinTech, network effect, wisdom of the crowd

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Initial coin offerings, or ICOs, have recently emerged as a popular alternative venture financing method. In a typical ICO, an entrepreneur raises capital by pre-selling a “token” which gives its owner the right to use the company’s product or service once it is developed. Many token owners also expect to resell their holdings for financial gains. These features blur the boundary of product pre-sale and security issuance.

Research firm Autonomous Next reports $1.3 billion in global ICO proceeds in just the first half of 2017.¹ This startling growth could be interpreted as either a testimonial of a laudable new innovation, or evidence of a dangerous irrational exuberance. Since ICOs do not fit neatly into existing securities or consumer-protection laws, regulators are concerned of ICOs presenting new opportunities for loopholes exploitations or even fraud.² Indeed many ICOs are difficult to justify either as products or investments.³

One potential regulatory response is to ban ICOs completely. Indeed, some jurisdictions are cracking down: Chinese authorities banned all ICOs in early September 2017, followed by South Korea later that month. This reaction is understandable given regulators’ concerns over protecting market integrity and maintaining financial stability. But such an one-size-fit-all approach also comes at a cost. Stifling a new idea may put one jurisdiction at a competitive disadvantage against those that permit or even promote innovations, if the innovation ultimately turns out to be valuable.

Other regulators have followed a case-by-case approach. For example, in its July 25, 2017 Investor Bulletin, the SEC states that “depending on the facts and circumstances of each individual ICO, the virtual coins or tokens that are offered or sold may be securities”.⁴ In Canada, the Ontario Securities Commission (OSC) approved the ICO of TokenFunder,

¹ Compared to $4 billion same-period global angel and seed capital investments reported by TechCrunch. Total number of ICO proceeds year-to-date has exceeded $2 billion (Wall Street Journal).
²For example, the SEC has prosecuted Maksim Zaslavskiy for alleged fraud in REcoin and DRC ICOs.
³A widely-cited example is Synthorn (http://synthorn.com/), which proposes to sell a synthetic rhinoceros horn aphrodisiac using the Ethereum blockchain. The Synthorn white paper is only three pages long, with only twelve words on market risk.
⁴See here.
even after issuing warnings against ICOs earlier in the year. But a case-by-case approach has its own problems: A lack of clear rules *ex ante* adds another source of risk for startups, investors, and other stakeholders in the the already risky early stage financing world. Table 1 provides a chronicle summary of global regulatory responses to ICOs.

In sum, regulators and practitioners are in urgent need of an effective rule-based framework for regulating ICOs, which preempts fraudulent issuance while permitting if not promoting issuances that create economic values, if any. The first step towards such a framework is thus to have a clear understanding of the fundamental economic value an ICO creates. Yet despite the widespread media attention paid to ICOs, there has been little analysis on just what that value might be.

This paper attempts to fill this gap. We address the fundamental question of when, and by what economic mechanism, the ICO structure may create value for entrepreneurs and consumers – and, just as importantly, when it does not. Our model builds on the observation that many well-received ICOs have helped to build a platform or marketplace. Examples include Ethereum, which is building a decentralized virtual machine as infrastructure for smart contract execution; Filecoin, which is setting up a network to allow peer-to-peer storage space sharing. We focus ourselves on the values of ICOs for launching such platforms.

A salient feature of a platform is that its value is largely driven by the interactions among its users who benefit from each others’ participation. We highlight two related channels based on this insight that both give values to doing an ICO. First, platform users’ directly benefiting from each others’ participation generates a strategic complementarity often known as “network externality”: a user’s gain from joining a platform increases with the number of other users. Second, information about the platform quality dispersed within the user base incentivizes each user to learn the “wisdom of the crowd” so as to make more informed participation decisions.

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5See here and here.
The presence of a network externality (also known as a network effect) imposes a critical mass requirement for a platform: if the platform has not already attracted a significant number of users, the surplus it can bring to new users will be too low to justify their participation. This creates a chicken-and-egg problem: if new users do not participate, how could the platform attract a critical mass in the first place? Without an ICO, the platform must lower the price of its product or service to all users to ensure sufficient participation. This decreases the entrepreneur’s profits, without creating any expected social surplus. Some platforms with large fixed costs may not even be launched at all. We argue that an ICO helps to overcome this critical mass constraint.

The intuition behind how the ICO helps the platform overcome a critical mass constraint could be illustrated by a simple two-player game. Suppose there are two prospective users of a platform. Each user can spend $C$ to get access to the platform, and enjoy a surplus of $S > C$ if and only if the other user also joins. Hence the payoff matrix is:

<table>
<thead>
<tr>
<th></th>
<th>join</th>
<th>quit</th>
</tr>
</thead>
<tbody>
<tr>
<td>join</td>
<td>$(S - C, S - C)$</td>
<td>$(-C,0)$</td>
</tr>
<tr>
<td>quit</td>
<td>$(0,-C)$</td>
<td>$(0,0)$</td>
</tr>
</tbody>
</table>

Clearly there are two Nash equilibria in this coordination game: either both users join the platform, or neither joins. An entrepreneur launching the platform would like to avoid the second inefficient equilibrium in which she gets zero payoff.

One simple way to avoid the self-fulfilling bad equilibrium is to simply designate one user to be a first-mover and make the first move perfectly observable to the follower. By breaking a simultaneous game into two stages, the entrepreneur effectively converts multiple Nash equilibria into a unique perfect equilibrium, in which the efficient outcome will be selected. Furthermore, we prove that even if there is no designation, i.e. both users could self-select to be the first or second mover, the mere existence of two stages motivates both users to join the platform immediately. Section 1.2 leverages this insight to explain several
empirical observations about ICO structuring, including the relationship between private pre-ICO rounds, Simple Agreements for Future Tokens (SAFT), public rounds of ICOs, and formal platform launches. Our analyses could also provide a framework for future studies of the use and design of escalating price schedules often observed in public token sales.

The “wisdom of the crowd” aspect of a platform kicks in when prospective consumers are heterogeneously informed. In a static game without ICOs, only consumers with relatively high signals will join, even if full participation in the platform is efficient. In such cases, the entrepreneur may be able to induce more participation by setting a low price, but full participation is never obtainable. Furthermore, the loss of profits due to price cutting may prevent some positive NPV platforms with large fixed costs from being launched at all, creating a social welfare loss. An ICO addresses this problem by creating a second stage for consumers to join the platform. Those with high signals join at the initial stage; then their decisions, in conjunction with the token price, will be informative about the value of the platform. For a valuable platform, participation increases at the second stage, creating a social surplus, some or all of which can be appropriated by the entrepreneur.

While emphasizing the “wisdom of the crowd” benefit, we caution that the learning channel may be abused if the criteria for a “crowd” do not apply, i.e. if the user demography deviates from being dispersed and large/highly influential stakeholders could strategically manipulate public learning. This concern is articulated by the SEC in its Nov 1st, 2017 Investor Alert against celebrity-endorsed ICO deals. Many notable deals also seem to be preempting such abuses by getting rid of private influencers, or by limiting the individual purchase amount. Our model provides a framework to analyze potential abuses and a trade-off between the pros-and-cons of introducing an ICO.

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7See the Blockstack ICO for examples of ditching private rounds (https://www.coindesk.com/a-more-equitable-ico-why-blockstack-said-no-to-a-token-pre-sale/) and the Kik ICO for limiting the individual purchase amount.
Our results provide several implications for policymakers and practitioners as well. First, we provide a rationale to argue against universal bans adopted by China and Korea. A universal ban of ICO for fear of its (real) problems may risk throwing the baby out with the bathwater. Second, a proposed ICO should explain why a platform-like feature is an essential feature of the project’s business model. While we do not necessarily rule out other channels in which ICOs could create value, we do note that any such benefit should be subject to a similarly rigorous analysis as pursued in this paper. Third, we endorse the SEC’s warnings against potential abuse by celebrity endorsed ICO deals, by rigorously modeling its possibility and the incentives behind. We emphasize the regulatory role of disclosure requirement of off-chain activities related to ICO issuances. Finally, we provide support for the SEC’s “substance” principle, by showing that in contrast to how they are often described, many tokens serve as devices to facilitate a successful platform launch without necessarily serving as a \textit{financing} method. These tokens should not be simply viewed as securities for financing purposes that naturally fall under the jurisdiction of existing securities laws; but rather as part of the operation process of a platform-like project, which fuel the build-up of network effects and spur the growth of socially valuable enterprises.\footnote{A recent statement by Singapore’s \textit{de facto} central bank echoes our stance. See here.}

Our results are also of technical interest along several dimensions. We describe ICOs as a new mechanism to overcome coordination problems, in addition to well known approaches such as introducing deposit insurance against inefficient bank-runs (Diamond and Dybvig (1983)). The technical tools used in the second half of our paper is also inspired by the global-games literature (Carlsson and Van Damme (1993), Morris and Shin (1998), and Goldstein and Pauzner (2005), etc). Our results are also of interest in the general problem of launching and pricing within a platform that connects users with each other, as studied in a large literature reviewed below. Finally, the ICO demonstrates the value created by dynamic interactions in the presence of informational frictions, as explored generally in papers such
as Daley and Green (2012), although our mechanism is different from theirs.

**Related literature**  To our best knowledge, we are the first to theoretically model ICO and analyze its value creation and related topics. One of the identified channels through which ICO creates value contributes to a growing economic literature on the wisdom of the crowd. Surowiecki (2005) gives an introduction of the concept. Galton (1907) provides original empirical evidence from an English weight-judging competition, and Da and Huang (2015) provides recent empirical evidence from an online earnings forecast platform.

Interpreting ICO as a pre-sale of tokens, our results are closely related to the crowdfunding literature. Strausz (forthcoming) and Ellman and Hurkens (2015) study the optimal reward-based crowdfunding design with a focus on a trade-off between improved screening/adaption and worsening entrepreneur moral hazard/rent extraction, respectively. Chemla and Tinn (2016) theoretically demonstrates how crowdfunding could help entrepreneurs take informed investment choices through learning learning from consumers’ crowd wisdom. Xu (2016) and Li (2015) provide empirical evidence that in crowdfunding entrepreneurs and follow-up investors do respectively learn from the crowd wisdom.

In the context of investment crowdfunding, Brown and Davies (2017) question several existing crowdfunding designs by showing that with all-or-nothing as well as fixed funding target and pro-rata payoff in place, a well-informed crowd could collectively behave as if uninformed due to coordination failure. By removing these existing designs, Li (2017) demonstrates how profit sharing could help investors learn from their peers, and therefore indirectly inform entrepreneurs of the investment community’s wisdom of the crowd.

Our comparison of all-or-nothing and keep-it-all clauses in ICO is inspired by discussions of such features in reward-based crowdfunding. While Cimon (2017) shows that the all-or-nothing feature is effective based on a real option argument, several recent studies have also questioned its efficiency from alternative perspectives. For example, Kumar, Langberg and
Zvilichovsky (2015) find that due to price discrimination against pivotal investors, existing crowdfunding structures may lead to a distorted phenomenon in which reducing the cost of capital to entrepreneurs may unintentionally reduce production and welfare. Cumming, Leboeuf and Schwienbacher (2015) compare keep-it-all versus all-or-nothing financing, and show that keep-it-all mechanisms are better for small, scalable projects. On the other hand, Chang (2015) shows that all-or-nothing funding generates more revenue than keep-it-all funding by helping the entrepreneurs learn market value as all-or-nothing funding complements borrowing. Belleflamme, Lambert and Schwienbacher (2014) emphasize the role of private benefits in determining an entrepreneur’s choice between crowdfunding via pre-orders and selling equity claims. Grüner and Siemroth (2015) regard crowdfunding as a mechanism in which consumers signal future product market demand via investment and compare with intermediated investment. Hakenes and Schlegel (2014) analyze a model with endogenous information production and debt-based crowdfunding, and highlight the winner’s curse and the natural hedge from not financing bad projects.


Though not directly related to our paper, Dindo and Massari (2017) derive a behavioral foundation for the wisdom of the crowd. Kremer, Mansour and Perry (2014) study one form of implementation of the wisdom of the crowd by characterizing the optimal disclosure policy of a planner who maximizes social welfare in a setting where agents arrive sequentially and
choose one from a set of actions with unknown payoffs. Kovbasyuk (2011) investigates a related but different question of how uninformed investors learn the crowd wisdom of experts.

1 ICO helps break through network effects

In this section, we lay out a simple model to illustrate how ICOs can be used to overcome coordination failure when the underlying project is characterized by a network externality, meaning that the benefit to each consumer from accessing the platform increases with the number of participants. While established firms often benefit from network effects, start-ups in industries featuring network effects often need to spend significant resources to build up a “critical mass” before ever taking off.

Before we lay out our formal model setup, to further motivate the concept of network externality in the context of ICO Section 1.1 first presents several cases of how network externality prevails in ICO related project development.

1.1 Network effects everywhere in the blockchain universe

Network externalities exist in many business models, especially those for which ICOs are common. We list several aspects of the network externality and notable corresponding ICO cases below.

Social network Social networks are a quintessential example where platform success largely hinges on network externalities. If none of your friends are following MySpace anymore, there is little value for you to be active on MySpace either. On the other hand, if many of your friends are sharing interesting things on Facebook, you will enjoy high utility from engaging in the Facebook community. Under our reasoning, social media companies characterized by strong network externalities are likely to use ICOs to achieve the efficient
equilibrium outcome with large scale participation.

Consistent with this logic, social media platform Kik launched a crowdsale which offers buyers the chance to purchase Ethereum-based tokens known as Kin that will serve as a tradable internal currency within Kik’s social media universe and power future apps on its platform.\(^9\) 10,026 individuals from 117 countries contributed 168,732 ETH (about $48 million dollars) to the public ICO, which adds to the $50 million raised in an earlier round of private pre-ICO.\(^10\) According the firm’s press release, a $98 million ICO proceeds makes Kin “one of the most widely held cryptocurrencies in the world”.

A notable feature of Kik’s ICO is that it imposes a purchase cap on how many Kins a buyer can purchase. This does not seem to be a reasonable move if the company’s goal is solely to maximize revenue, but it may help address the network externality, as we show below. Furthermore, Kik explicitly chose an ICO instead of traditional VC financing to foster a community, as explained here. We will return at the end of our paper to a comparison of these strategic and financing motives behind an ICO.

**Sharing economy** Network effects also play a crucial role in developing a sharing economy, as often discussed in the two-sided markets literature. For illustration, notice that more riders on Uber incentivizes more drivers to participate, as they would expect higher and more steady traffic; similarly, more drivers providing ride-sharing incentivizes more riders to use Uber, as they view Uber as a more convenient and reliable traveling method. Hence we expect sharing platforms to take advantage of ICOs in order to attract the necessary critical mass so that network externality would work toward the efficient equilibrium.

As an example of this intuition, decentralized data storage network Filecoin launched an ICO via CoinList, a joint project between Filecoin developer Protocol Labs and startup

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\(^9\)Kik currently has up to 15 million monthly active users.

investment platform AngelList, and raised approximately $205.8 million over the next month. This added to the $52 million collected in a private presale catered to notable VC firms including Sequoia Capital, Andreessen Horowitz and Union Square Ventures, etc.\textsuperscript{11} Filecoin operates like an “Uber for file storage”, which aims to provide a decentralized network for digital storage through which users can effectively rent out their spare capacity. In return, those users receive filecoins as payment.

The Filecoin ICO, like many other ICO deals, adopts a sales model in which the minimum price buyers must pay rises as more investors join in, which is consistent with both the motive to subsidize first movers and the fact that later movers are likely to enjoy higher utility thanks to anticipated larger network effect.

**New blockchains** As a decentralized database, a blockchain itself is an example of network effect. When more users are maintaining a blockchain (or mining in the specific case of the Bitcoin blockchain), its security will be enhanced, and each user will enjoy a higher utility (thanks to less concern of single-point-of-failure or censorship) from using the blockchain. It is hence not surprising to see token sales to be widely adopted by entrepreneurs who are developing new blockchains.

The most salient example is the large-scale crowdsale of Ethereum. As a decentralized computing platform featuring smart contract functionality, Ethereum extends the Turing-incomplete Scripting language embedded in Bitcoin and develops a new blockchain to support the Ethereum Virtual Machine (EVM), a Turing-complete virtual machine, which execute scripts using an international network of public nodes. The project was funded during July-August 2014 by the crowdsale of “ether”, a cryptocurrency token used for transfers between accounts as well as compensation to participant nodes for computations performed. The

\textsuperscript{11}That launch day “was notable both for the large influx of purchases of Simple Agreements for Future Tokens, or SAFTs (effectively claims on tokens once the Filecoin network goes live), as well as the technology issues that quickly sprouted as accredited investors swamped the CoinList website.” See https://www.coindesk.com/257-million-filecoin-breaks-time-record-ico-funding/.  

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system went live on 30 July 2015, with 11.9 million coins "premined" for the crowdsale. Today, Ethereum has been used as the platform for most other coin offerings.

A separate example comes from the recent open-cap ICO conducted by Tezos. In order to create “a new decentralized blockchain that governs itself by establishing a true digital commonwealth”, Tezos raised 65,703 bitcoins and 361,122 ethers (around $232 million) during the July 1 - 14, 2017 crowdsale window. Partially due to the strong network effect embedded in the nature of the project, the campaign end up being the largest crowdsale ever by the time of its issuance.

**Marketplaces** Fostering a well-functioning market has long been recognized in both the finance literature and practice as an example of a coordination game. Barclay and Hendershott (2004) test the theory of “liquidity externality” by studying the after-hours stock market. Most stock exchanges hold policies to subsidize a subset of “market makers” to obtain the critical mass for network effects to work (e.g. historically offering privileges to designated market makers, or recently offering rebates to liquidity providers). Hence we expect startups launching exchanges or marketplace-like platforms would necessarily find ICOs to an effective tool.

Indeed, t∅, a subsidiary of online e-commerce marketplace Overstock.com, formally announced on Oct 24, 2017 a campaign to sell Simple Agreements for Future Tokens (SAFTs), a model also used by the Filecoin ICO. According to the company, the t∅ ICO will first run as a private pre-sale from Nov. 15 to Dec. 31 to accredited investors. “The proceeds from the ICO will help the company scale its technology development and regulatory teams, as well as either build or take over a custody and clearing firm”.

Prediction and online gambling market is another example of marketplace featuring network externality, as placing bets requires a counterparty. A larger market also improves

12https://www.coindesk.com/overstocks-launching-initial-coin-offering-next-month/
risk management for the market maker. It is thus not surprising that prediction and online gambling markets have been frequent adopters of ICOs. Examples include Unikrn, whose underlying UnikoinGold is developed to serve as decentralized token for e-sports and gaming, fetched $15 million in pre-sale from private backers including Mark Cuban, and 110,000 ethers in public token sale; Augur, which attempts to build a decentralized network for accurate forecasting, which was funded via an online crowdsale during August and October of 2015. It is worth noting that in addition to featuring network effect, as a decentralized platform Augur also builds on the notion of the wisdom of the crowd.

1.2 ICO coordinates the efficient equilibrium

This section lays out our benchmark model for analyzing the network effect. We do not consider any fundamental uncertainty or consumer heterogeneity for the moment, which will be dealt with in Section 2. A risk-neutral entrepreneur can incur a fixed cost $K$ to launch a platform. Once that cost is incurred, the entrepreneur can charge a per-capita cost $C$ to $N$ prospective consumers for access to the platform. Network effects require that the platform must attract a critical mass before it can take off. We model this critical mass requirement in a simple way, by assuming that only if more than $M < N$ consumers join the platform would any participant get to enjoy a positive utility from the platform. Therefore a representative consumer’s payoff as a function of his action, and others’ actions, is:

$$
\begin{cases} 
0, \text{if he does not participate} \\
-C, \text{if he participates but less than } M \text{ consumers join} \\
S - C, \text{if he participates and at least } M \text{ consumers join}
\end{cases}
$$

where $S > C > 0$ denotes consumer surplus and is assumed (for the moment) to be identical across types. Once a consumer joins, this decision will not change, as the cost $C$ is sunk.
The dynamics of the platform launch is captured by an exogenous variable $T$, which denotes the number of periods in which prospective consumers can choose to join or quit the platform. This quantity can be thought of as capturing the cost of keeping the platform open while waiting for the critical mass to accumulate.

A special case arises when $T = 1$, or in other words, the entrepreneur has to launch the platform to all prospective consumers simultaneously. In this simultaneous game it is easy to verify that there are multiple equilibria: either all prospective consumers join the platform, or none does. From a social welfare perspective, the second equilibrium represents a social welfare loss to all players. And the fear of this inefficient equilibrium happening may prevent the entrepreneur from launching an otherwise valuable platform at all.

When $T > 1$, the subgames at future dates may help ease the coordination failure of the one-shot game. This is summarized in the following two theorems.

**Theorem 1.1** (Designated sequential game). When $T \geq M$, and the entrepreneur can designate all prospective consumers to move sequentially within at least $M$ stages, a unique perfect equilibrium exists in which at least $M$ consumers join the platform, the critical mass constraint is satisfied, and the efficient outcome is obtained.

*Proof.* We only consider the case in which $T = M$. Solving backwards, the last mover chooses to join if at least $M - 1$ players choose to join before him. Hence, anticipating this the second-to-last mover will choose to join if at least $M - 2$ players before him choose to join. Anticipating this, the third-to-last mover will choose to join if at least $M - 3$ players before him choose to join. In general, the $(M - 1)^{th}$-to-last mover will choose to join if at least $M - (M - 1) = 1$ players before him choose to join. Anticipating all this, the first mover will always choose to join so long as there is at least $M$ stages. 

**Theorem 1.2** (Self-selected sequential game). When $T \geq M$, and the entrepreneur can allow all prospective consumers to move sequentially within at least $M$ stages, then a unique
perfect equilibrium exists in which all consumers join the platform immediately, the critical mass constraint is satisfied, and the efficient outcome is obtained.

Proof. By induction. First, when \( M = 1 \), the statement trivially holds, because any individual consumer will join the platform immediately and the efficient outcome will be achieved. Second, assume the statement holds for \( M = m - 1 \), or in other words, when the platform only has value if at least \( m - 1 \) consumers join, and all \( N \) consumers are allowed to move sequentially within at least \( m - 1 \) stages, then all consumers will join the platform immediately and the efficient outcome is obtained. Under this assumption, the statement will also hold when \( M = m \). This is because anticipating the outcome with \( M = m - 1 \), each consumer will join in the first stage as the subgame that follows would be exactly identical to the \( M = m - 1 \) case.

The two theorems state that if the product launch can last long enough, inefficient coordination failure will not happen and the efficient outcome is obtained.

When the platform launch cannot last long enough though, and in particular when \( T < M \), inefficient coordination failure is always a possibility. In such a case, however, the entrepreneur could eliminate the inefficient equilibrium by introducing an ICO. Intuitively, the ICO serves as additional rounds for prospective consumers to participate in the platform.

**Theorem 1.3.** When \( T < M \), so that there is fear of an inefficient coordination failure during platform launch, introducing an ICO that contains \( M - T \) rounds helps eliminate such concerns, and improves social welfare. All prospective consumers will join during the ICO.

Proof. An ICO with \( M - T \) rounds of participation opportunities breaks the product launch into \( M \) stages. By Theorem 1.2 the efficient outcome is obtained.

Theorem 1.3 explains the size of many observed deals. The media has often quoted some ICOs as “fetching millions in minutes” and attributes the phenomenon to irrational
exuberance. While we do not rule out the possibility of bubbles and frenzies currently in
the ICO market, as we discuss in more detail in Section 3, the large scale of certain ICO
deals could also have rational foundations: while accelerating the build-up of network effects
and preventing inefficient coordination failures, they also effectively front-load prospective
consumer demands.

The $M-T$ stages in an ICO deal have the natural empirical correspondences of escalating
token prices. As long as the ICO can be structured in an adequate number of stages, fears
of coordination failures during a platform launch can be eliminated. When the public token
sale cannot provide adequate number of stages to eliminate coordination failure, however, a
public ICO may not be enough and the entrepreneur may resort to private pre-ICOs.

**Theorem 1.4.** Suppose $T < M$, so that there is fear of an inefficient coordination failure
during platform launch, and a public ICO cannot add adequate number of additional rounds.
The entrepreneur can designate some first movers, offer them adequate subsidies to ensure
participation, and ensure a critical mass of $M$ consumers join the platform so that the socially
efficient outcome is obtained.

**Proof.** Suppose a public ICO can only add at most $Q < M - T$ rounds of additional par-
ticipation opportunities, then in order to ensure at least $M$ participants in $T + Q$ rounds,
the entrepreneur could designate $M + 1 - T - Q$ first movers and ensure their participation
in period one. Then starting from period two, the platform would only need $T + Q - 1$
participants within $T + Q - 1$ periods, which is guaranteed by Theorem 1.2.

The designated first movers in Theorem 1.4 correspond to those private round pre-ICO
participants invited by the entrepreneurs. They typically receive large discounts during the
pre-ICO round, corresponding to the subsidies in Theorem 1.4.

In summary, we demonstrate that for projects that need to quickly build up network
effect, an ICO or pre-ICO helps overcome the critical-mass constraint. While ICOs do raise
funds, they are more appropriately viewed as part of the operational process of project launches. In the next section, we introduce uncertainty and provide an alternative channel for ICOs to create value, which will be compared with the network effect channel later.

2 ICO harnesses the wisdom of the crowd

The multi-stage nature of ICOs offers an alternative channel other than breaking the network effect to create value: When the consumer community is adequate dispersed, and they possess useful information about the platform prospect in a decentralized way, introducing an ICO also helps harness the wisdom of the crowd.

We assume a continuum of consumers in this section for both exposition ease and highlighting the decentralized assumption about the consumer community. To be realistic as well as consistent with the analysis in the previous section, we also conduct all analysis with a discrete number of players in Appendix B, where we also illustrate the importance of a disclosure requirement of celebrity/high-influence endorsement to prevent manipulation.

A risk-neutral entrepreneur can incur a fixed cost $K$ to launch a platform, after which the entrepreneur can charge a per-capita cost $C$ to a unit continuum of consumers for access to the platform. An individual consumer’s payoff as a function of his action is:

$$\begin{cases} 
0, & \text{if he does not participate} \\
S - C, & \text{if he participates}
\end{cases}$$

The potential values of $S$ are normalized to $S \in \{0, 1\}$, and the realization of $S$ is the state of nature. All agents share the common prior $P(S = 1) = p$. Each consumer gets a noisy private signal $X$ about the value of $S$, and this is the only difference among them. We assume that the signals $X$ are distributed according to the conditional distribution functions $(X|S = 1) \sim F_H$ and $(X|S = 0) \sim F_L$. Conditional on the realization of $S$, the signals $X$ are
independent of each other. Define \( F(x) \equiv pF_H(x) + (1-p)F_L(x) \). Without loss of generality, we assume the actual platform launch takes place within only one stage, i.e. \( T = 1 \).

We assume that \( f(x) \equiv F'_H(x)/F'_L(x) \) follows the monotone likelihood ratio property (MLRP), \( f'(X) > 0 \). The MLRP implies that \( F_H(x) < F_L(x) \) for all \( x \) above the lower bound of the support of \( X \). In other words, for any given \( x \), knowing \( F_S(x), S \in \{H, L\} \) is perfectly revealing of the underlying state \( S \). This property will be useful in the derivation of the ICO case later.

### 2.1 The entrepreneur’s problem without an ICO

Given a price \( C \) to join the platform, consumer \( i \) joins if and only if \( \Pr(S = 1 \mid X_i) \geq C \). Thus, a cutoff \( x^* \) is defined by setting this expression to equality,

\[
\Pr(S = 1 \mid x^*) \equiv C \tag{1}
\]

The entrepreneur’s problem is \( \max C \times (1 - F(x^*)) \), which yields the first-order condition

\[
m_F(x^*) = C \times \frac{dx^*}{dC} \tag{2}
\]

where \( m_F \) is the Mills ratio corresponding to the distribution \( F \), defined as \( m_F(x) \equiv \frac{1-F(x)}{F'(x)} \).

The derivative \( \frac{dx^*}{dC} \) comes from implicitly differentiating (1), which defines \( x^* \).

This is a standard monopolist’s problem: Condition (1) characterizes the consumer’s demand, and condition (2) characterizes the entrepreneur’s optimal price policy subject to that demand. Define \( C^* \) and \( x^* \) as the solutions to the pair of equations (1) and (2).

From these conditions we can see that there will be less than full participation, regardless of the state of nature, because no signal is high enough to guarantee that the state is good. Moreover, even when the state is good so that the potential surplus from launching the
platform is 1, the entrepreneur captures less than this since both the price of the coin and the mass of participants will be less than one.

In general, the problem is that the static nature of the game prevents any state-contingent payoffs. The ICO will introduce dynamics that loosen this restriction and thereby increase efficiency.

2.2 The entrepreneur’s problem with an ICO

We model the ICO as a pre-sale of tokens, each of which provides the right for one consumer to access the platform once it is launched later. Consumers can choose to join at time 0 or 1, and the entrepreneur sets prices $C_0$ and $C_1$ that are specific to these dates. We shut down any discounting between the two dates. The mass who join at time 0 is labeled $\mu$ and is public knowledge as of time 1. This mass constitutes the information that is released via the ICO, which is the role of the ICO in our model.

We will show that, by combining $\mu$ and $C_0$ with the common-knowledge distribution of signals and states, all agents perfectly observe the state at $t = 1$. If it is revealed that $S = 1$, all consumers join the platform at $t = 1$; otherwise none do. Thus if $S = 1$, the entrepreneur sets $C_1 = 1$ and captures all remaining surplus from the consumers who have not yet joined.

To show this, we characterize the time-zero participation decision by the consumers. At time zero, consumer $i$ will make his decision by forming expectations about prices and information at time 1. He will join if and only if $Pr(S = 1|X_i) - C_0 \geq 0$ and $Pr(S = 1|X_i) - C_0 \geq E[Pr(S = 1|X_i, \mu) - C_1^*|X_i]$. Applying iterated expectations to simplify the second of these, consumer $i$ participates at time zero if and only if

$$C_0 \leq \min(Pr(S = 1|X_i), E[C_1^*|X_i]) \quad (3)$$

This implies that the ICO participants are those who expect that both the surplus and the
later price will be higher than $C_0$. In fact, these two conditions are redundant to each other: Because $C_i^* = 1$, we have $E[C_i^*|X_i] = E[\mathbb{1}\{S = 1\}|X_i] = Pr(S = 1|X_i)$. So we ultimately have a simple cutoff $x_o^*$ defined by

$$C_0 = Pr(S = 1|x_o^*)$$

(4)

Notice that this mapping from price to cutoff signal is identical to (1). The price $C_0$ in this section may be different from the optimal $C^*$ derived in that section (and we will show that it is), but given any value of $C_0$, we have the same logic as before, that the cutoff value of $x^*$ will be the one at which the conditional probability of the good state equals that price.

Given a value of $C_0$, all agents with $X_i \geq x_o^*$ join the ICO at time 0, so all agents then observe $F_s\left(f^{-1}\left(\frac{C_0}{1-C_0} \times \frac{1-p}{p}\right)\right)$. This expression can only take on one of two potential values based on the potential values of $s$, and both of these potential values are common knowledge. Therefore, immediately after the ICO, everyone perfectly knows the state, verifying the conjecture made above. If it was revealed that $S = 1$, then all agents join the platform at time 1, and otherwise none do.

Finally, we analyze the entrepreneur’s problem at time zero: The entrepreneur chooses $C_0$ to maximize expected profit,

$$\max_{C_0} C_0 \times (1 - F(x_o^*)) + p \times F(x_o^*)$$

(5)

Compared to the no-ICO problem, this adds in a probability $p$ that the state is revealed to be positive and all remaining customers buy in at price 1. This leads to the first-order condition

$$m_F(x_o^*) = (C_0 - p) \times \frac{dx_o^*}{dC_0}$$

(6)

Comparing with (2), we see that the potential for second-stage profits increases $C_0$ above
the no-ICO price, via $p$. Intuitively, the entrepreneur is willing to accept a greater risk of losing customers by pricing too high at time zero, anticipating that if $S = 1$ he will be able to extract greater rents from these consumers later on.

Our main result in this section is the following

**Theorem 2.1.** The entrepreneur achieves greater expected profit with than without the ICO.

**Proof.** The entrepreneur would already be strictly better off with the ICO than without simply by setting $C_0$ equal to $C^*$ from the non-ICO case, because with probability $p$ he can now extract full surplus from everyone who did not buy in at time zero. In fact, in equilibrium he sets $C_0 > C^*$, but this is only done if it weakly increases his profits relative to setting $C_0 = C^*$. \(\square\)

**Discussion.** The core intuition behind this results is that the entrepreneur is much better off when he has two stages over which to sell his product. However, this effect should not be interpreted as price discrimination: Conditional on a good state, the price actually increases over time, and the agents with the highest willingness to pay (the highest signals) actually pay the lowest price. Instead, the key mechanism here is the wisdom-of-the-crowd assumption. The ICO reveals the highest signals to all consumers, allowing all to judge the quality of the platform. Unlike the static game, there is then an additional time period at which the entrepreneur can sell access to the platform and realize the social surplus from doing so.

### 2.3 Allowing for speculation in the ICO

ICOs are often described as an investment opportunity for those who buy in, and as an alternative financing source to debt or equity for the companies who undertake them. In this section, we analyze the gains to speculating in an ICO.
We introduce a unit mass of “speculators” who derive no utility from joining the platform, but can buy access to the platform at time zero and re-sell it later. They get their own signals about the platform quality separately from the consumers. The entrepreneur has no way to distinguish them from the other agents, so they pay the same price as everyone else. We analyze the incentives of these speculators to buy and sell tokens at time zero and 1.

The main result of this analysis is that, while there may be a positive volume of speculative trade, this has no impact on the prices or allocations of the model and there are no economic profits to speculation. To be clear, speculators may expect a positive return to their investment, even unconditionally, but this is a fair return for the risk of platform failure and does not distort prices away from what was derived above.

We assume the entrepreneur commits not to change the supply of coins ex post. This is a credible assumption because, if the entrepreneur finds it beneficial to make this commitment, blockchain technology provides a mechanism for him to do so. This assumption was not relevant before, as the entrepreneur was the only seller, but with opportunistic speculators also selling at time 1 there may be an incentive to create additional coins without this assumption.

First, we show that the prices derived in the previous section are still an equilibrium, although the volume of trade may change. At those prices, speculators with signals above \( x_0^* \) buy, anticipating that if \( S = 1 \) they can resell at time one for a price of 1. This means there is twice as much volume as without resale. However, at time one, the total supply of coins on the market is the same; the only difference is that relatively less of that supply comes from the entrepreneur. At a price of 1, none of the sellers want to keep their coins, and all of the buyers are willing to buy, so this price is still an equilibrium.

A separate question is whether any other prices might constitute an equilibrium as well. More precisely, it might seem natural that a price war could break out among sellers at \( t = 1 \), driving the price of tokens below 1. The equilibrium described in the previous paragraph
implicitly has sellers at time 1 colluding not to do this, but it might seem that any one of
them has an incentive to do so if they could.

However, note that the aggregate supply of coins sold at time 1 does not change. Each
seller gets a mass of demand equal to the mass of coins that he sells; even if a different seller
tried to undercut the entrepreneur with a lower price, this would not decrease the residual
demand facing the entrepreneur after that seller exhausted his supply. Thus, regardless of
what other agents do, the entrepreneur (and every seller in the model) can still charge a
price of 1 to his buyers at the second date. That price therefore becomes the unique optimal
price for every agent in the optimal.

Nevertheless, the presence of the speculators does force the entrepreneur to sell more
coins at the first stage. Does this ultimately decrease his expected profit? Can he increase
the price at time zero? Let $F^s$ be the CDF of signals to the speculators. We simply change
the entrepreneur’s problem to

$$\max_{C_0} C_0 \times \min (1, 1 - F^s(x^*_0) + 1 - F^s(x^*_0)) + p \times \max (0, F(x^*_0) - (1 - F^s(x^*_0)))$$

(7)

First, consider the possibility that the speculators demand more the entire supply at time
zero. This is inconsistent with equilibrium: In this case, the only market-clearing price at
time 1 will be less than one, and all speculators know this and will not demand to buy any
coins. Therefore, we can restrict attention to cases where the speculators’ demand is small
enough to not exceed one at time zero.

With that observation, we can focus on the first-order condition as characterizing the
solution to the problem. This condition is

$$\frac{1 - F(x^*_0) + 1 - F^s(x^*_0)}{F'(x^*_0) + F^s'(x^*_0)} = (C_0 - p) \times \frac{dx^*_0}{dC_0}$$

(8)

which is a straightforward generalization of (6).
We can rewrite the LHS of (8) as a weighted average:

\[
\frac{1 - F(x_0^*) + 1 - F^s(x_0^*)}{F'(x_0^*) + F^s'(x_0^*)} = \frac{F'(x_0^*)}{F'(x_0^*) + F^s'(x_0^*)} \times m(x_0^*) + \frac{F^s'(x_0^*)}{F'(x_0^*) + F^s'(x_0^*)} \times m^s(x_0^*)
\]

If the speculators and investors draw signals from the same distribution, then this analysis shows that there is ultimately no effect on the entrepreneur’s revenue compared to the no-resale case. The mass of speculators selling at time 1 is completely offset by their buying at time zero, since the coins are fairly priced at both dates.

2.4 Adding a critical-mass constraint

In this section we combine the network effect and wisdom of the crowd and show the additional values an ICO could bring. We again model the critical mass requirement in a simple way, by assuming that the per-capita surplus $S$ is realized if and only if at least a measure $\alpha$ of consumers join the platform. Therefore an individual consumer’s payoff as a function of his action is:

\[
\begin{cases} 
0, \text{ if he does not participate} \\
-C, \text{ if he participates but there are less than } \alpha \text{ total participants} \\
S - C, \text{ if he participates and there are more than } \alpha \text{ total participants}
\end{cases}
\]

The rest is as in the core model: We normalize $S \in \{0, 1\}$, depending on the state of nature. All agents share the common prior $\mathbb{P}(S = 1) = p$. Each consumer gets a noisy private signal $X$ about the value of $S$, and this is the only difference among them. We assume that the signals $X$ are distributed according to the conditional distribution functions $(X|S = 1) \sim F_H$ and $(X|S = 0) \sim F_L$. Conditional on the realization of $S$, the signals $X$ are independent of each other. We continue to assume that $f'(X) > 0$ where $f(x) \equiv F'_H(x)/F'_L(x)$. 
2.4.1 Entrepreneur’s problem in a one-stage game

We first analyze the case in which there is no ICO. The entrepreneur makes the entry decision, and conditional on entering the market, sets the cost $C$ to maximize profit. While a high value of $C$ clearly increases that profit, two forces discourage the entrepreneur from setting the value of $C$ too high. First, as before, a high value of $C$ increases the minimum private signal $X$ that a consumer must have to find it profitable to join the platform. Second, conditional on an individual consumers’s private signal, the network effect further deters the consumer from joining, as she anticipates a smaller set of other consumers joining. The entrepreneur thus needs to choose $C$ to extract as much surplus from the consumers, while internalizing the effect of $C$ on the critical mass $\alpha$ requirement.

Formally, consumer $i$ joins the platform if and only if

$$\mathbb{P}(\text{at least } \alpha \text{ consumers join and } S = 1 \mid X_i) \geq C. \quad (9)$$

By Bayes’ rule, the probability in (9) is equal to

$$\mathbb{P}(\text{at least } \alpha \text{ consumers join } \mid S = 1, X_i) \times \mathbb{P}(S = 1 \mid X_i).$$

Due to no correlation in the signals conditional on the fundamental, the first term

$$\mathbb{P}(\text{at least } \alpha \text{ investors join } \mid S = 1, X_i) = \mathbb{P}(\text{at least } \alpha \text{ investors join } \mid S = 1). \quad (10)$$

The second term $\mathbb{P}(S = 1 \mid X)$ can be expanded as

$$\frac{p \times f_H(X)}{p \times f_H(X) + (1 - p) \times f_L(X)} = \frac{p \times f(X)}{p \times f(X) + (1 - p)}.$$
Hence, (9) is equivalent to

\[ \mathbb{P}(\text{at least } \alpha \text{ investors join } | S = 1) \times \frac{p \times f(X)}{p \times f(X) + (1 - p)} \geq C \]  

(11)

In equilibrium each investor follows a cutoff strategy of participating in the platform if and only if his signal is higher than some \( x^* \), which is the same for all investors due to the symmetry of the setup. Depending on the realization of the underlying state \( S \in \{H, L\} \), a measure of \( 1 - F_S(x^*) \) consumers (those with high enough signals) will participate. Given the structure of the economy and the entrepreneur’s choice of \( C \), consumers know with certainty whether this mass is greater than \( \alpha \).

The entrepreneur thus has two possible regions of price setting strategies: First, set \( C \) so low that \( 1 - F_H(x^*) \geq \alpha \); second, set \( C \) so high that \( 1 - F_H(x^*) < \alpha \). The second case is clearly ruled out in equilibrium, because in this case no consumer expects the critical mass requirement to be satisfied in any state of nature, so none of them will participate and the entrepreneur’s revenue would be zero. In the first case, \( \mathbb{P}(\text{at least } \alpha \text{ investors join } | S = 1) = 1 \), and so (11) reduces to

\[ \frac{p \times f(X)}{p \times f(X) + (1 - p)} \geq C \]  

(12)

and for a given \( C \) chosen by the entrepreneur, \( x^* \) is defined by setting the above expression to equality:

\[ \frac{p \times f(x^*)}{p \times f(x^*) + (1 - p)} = C. \]  

(13)

Hence, we obtain the entrepreneur’s problem below:
The entrepreneur’s problem  The entrepreneur chooses $C$ to maximize her payoff

$$pC \times (1 - F_H(x^*)) + (1 - p)C \times (1 - F_L(x^*)), \quad (14)$$

subject to

$$\frac{pf(x^*)}{pf(x^*)+(1-p)} = C \quad \text{(consumer IC)} \quad (15)$$

$$1 - F_H(x^*) = \alpha \quad \text{(critical mass)} \quad (16)$$

Attaching multiplier $\lambda$ to constraint (56), the first-order condition for this constrained problem is thus

$$m_F(x^*) = \left( C + \lambda \frac{F'_L(x^*)}{F'(x^*)} \right) \times \frac{dx^*}{dC} \quad (17)$$

Comparing condition (17) with condition (2) in Section 2, the difference is the new term inside parentheses. Because this term is always positive, we see that the platform is priced lower than it was without the critical-mass feature. This is intuitive: The lower price is the mechanism by which the entrepreneur induces participation by the critical mass $\alpha$.

2.4.2 Introducing ICO

Again ICO is interpreted as a pre-sale of tokens that give access to the platform once it is launched in the second stage. Without re-sale, the entrepreneur enjoys a profit of (before the fixed cost $K$)

$$pC_0 \times (1 - F_H(x_1^*)) + (1 - p)C_0 \times (1 - F_L(x_1^*)) + pS \times [1 - (1 - F_H(x_1^*))], \quad (18)$$

where $x_1^*$ denote the cutoff of signals above which the consumer will participate in the ICO. The first term represents revenues from the ICO, while the second term denotes revenues from the actual launch of the platform.

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A consumer will participate in the ICO if and only if

$$\mathbb{P}(S = 1|X) \geq C_0,$$

(i.e. participating in ICO does not expect a loss, and (for a continuum of consumers) no worse than waiting) or for the marginal consumer at the signal cutoff

$$\frac{p \times f(x^*_1)}{p \times f(x^*_1) + (1 - p)} = C_0$$

Hence with the introduction of ICO, the entrepreneur’s problem becomes the following

**The entrepreneur’s problem with ICO**  The entrepreneur sets $C_0$ to maximize

$$pC_0 \times (1 - F_H(x^*_1)) + (1 - p)C_0 \times (1 - F_L(x^*_1)) + pS \times [1 - (1 - F_H(x^*_1))],$$

subject to

$$\frac{p \times f(x^*_1)}{p \times f(x^*_1) + (1 - p)} = C_0 \text{ (consumer IC)}$$

We note that with ICO the entrepreneur’s problems is exactly the same as the one without the critical mass requirement. Without ICO, however, the entrepreneur faces an additional critical mass constraint. Hence ICO adds additional value by eliminating this constraint whenever it is binding.

Comparing the entrepreneur’s problem with and without the ICO illustrates two important implications of the ICO: First, with the ICO, the entrepreneur only needs to subsidize a smaller set of ICO participants: those with particularly high private signals about the social value of the platform. She can charge the full consumer surplus created by the platform to the remaining mass of consumers (the second term in (28)). ICO effectively serves as
a screening device in front of investors with different level of asymmetric information, and helps reduce the “lemon” discount. Second, thanks to the coordinating effect of the ICO participants, the entrepreneur no longer needs to take into account the $\alpha$ critical mass, hence relaxing constraint (56) when optimizing.

### 2.5 ICO expands social surplus

The role of the ICO in our framework is to incentive participation in cases where this would create social surplus. In this section, we show formally that the ICO therefore expands social surplus. To our knowledge, this is the first formal demonstration of a valuable economic role for ICOs, in contrast to most commentary which has focused on their facilitation of fraud and skirting of securities regulations.

Note that, in all cases, expected social surplus is equal to the mass of consumers who join the platform in the good state, times the probability $p$ of that state occurring. Consider first the model without the critical-mass constraint. Without an ICO, the mass of consumers who participate in the positive state is $1 - F_H(x^*)$. With the ICO, that mass is 1, as all consumers end up joining sooner or later. The same intuition holds with the critical-mass constraint: Without the ICO, some agents will fail to participate in the positive state, whereas with the ICO they all will at one of the two dates.

In any of these cases of our model, consumers receive none of the surplus created by the platform. This is because we assume that the platform provider can act as a monopolist and appropriate all surplus. However, this assumption could be relaxed. The important observation is that the increased profit to the monopolist arises due to the creation of surplus. In this sense, ICOs in our model serve a socially-valuable purpose.

We could also formalize the intuitions with several theorems. First, without ICO certain positive NPV projects may be forfeited.
Theorem 2.2. There exist values of $p$, $\alpha$, and $K$ for which projects are positive NPV yet not funded in equilibrium.

Proof. First define $\overline{K} \equiv pS$. Clearly a project has positive NPV if and only if $K < \overline{K}$.

Next define $\underline{K}$ as the entrepreneur’s revenue from optimally pricing the platform. Hence

$$\underline{K} \equiv \max_X \frac{p f(X)}{p f(X) + (1 - p)} [1 - F_H(X)]$$

if $1 - F_H(X) \geq \alpha$ at the optimal $X$, or otherwise $\underline{K} \equiv \alpha \tilde{C}$, where $\tilde{C}$ satisfies

$$\tilde{C} = \frac{p f(\tilde{X})}{p f(\tilde{X}) + (1 - p)}, \quad (21)$$

in which

$$1 - F_H(\tilde{X}) = \alpha. \quad (22)$$

It is easy to see that if and only if $K > \underline{K}$, the entrepreneur would suffer an expected loss if she incurred $K$ to launch the platform. In equilibrium such projects will be unfunded.

Hence inefficient coordination could happen for $p$ and $\alpha$ if as defined $\underline{K} < \overline{K}$, which is (after some simplifying algebra) if

$$(\alpha - p) f(\tilde{X}) < 1 - p, \quad (23)$$

where $\tilde{X}$ is defined as $1 - F_H(\tilde{X}) = \alpha$. \hfill \square

Theorem 2.3 redoes the analysis for the ICO case.

Theorem 2.3. For some $p$ and $\alpha$ there exists $\underline{K}$ and $\overline{K}$ such that projects with $\underline{K} < K \leq \overline{K}$ are positive NPV yet unfunded in equilibrium.
Proof. Similar to the case without ICO, define $K \equiv pS$. Clearly a project has positive NPV if and only if $K < \overline{K}$. Define $\underline{K}$ as

$$\max_x \frac{p \times f(x)}{p \times f(x) + (1 - p)} \times (1 - F_H(x)) + \times [1 - \times (1 - F_H(x))].$$

(24)

If and only if $K > \underline{K}$, the entrepreneur would suffer an expected loss if she incurred $K$ to launch the platform. In equilibrium such projects will be unfunded.

**Theorem 2.4.** For all $\alpha, p, f_H$, and $f$, we have $\overline{K} \geq \underline{K}$. Hence the parameter regions in which coordination failure happens is smaller when we introduce ICO.

Proof.

$$\underline{K} = \max_x \frac{p \times f(x)}{p \times f(x) + (1 - p)} \times (1 - F_H(x)) + \times [1 - \times (1 - F_H(x))]$$

$$\geq \frac{p \times f(\tilde{X})}{p \times f(\tilde{X}) + (1 - p)} \times (1 - F_H(\tilde{X})) + [1 - \beta \times (1 - F_H(\tilde{X}))]$$

$$\geq \frac{p \times f(\tilde{X})}{p \times f(\tilde{X}) + (1 - p)} \times (1 - F_H(\tilde{X}))$$

$$= \tilde{C} \times \alpha$$

$$= \underline{K}$$

2.6 Manipulation and fraud

We caution that unlike the network effect channel, the wisdom of the crowd channel may be subject to abuse and manipulation. Because follow-up consumers learn about the project type ($H$ or $L$) from both the price charged and the number of participants in ICO, one fraud the entrepreneur can commit is to offer private off-chain side payments to some individuals to induce higher ICO participation. The combination of higher ICO participation
and the public on-chain price may create a false impression upon follow-up consumers that the project is high quality. As long as the increase in proceeds the entrepreneur collects is higher than the side payment required, there is room for manipulation. We derive the parameter ranges in which such fraud can happen below.

The model framework is similar as before. A risk-neutral fraudulent entrepreneur incurs a fixed cost $K$ to launch a platform, after which the entrepreneur charges a monopolistic per-capita cost $C$ to a unit continuum of consumers for access to the platform. An individual consumer’s payoff is:

$$\begin{cases} 
0, & \text{if he does not participate} \\
S - C, & \text{if he participates}
\end{cases}$$

where $S \in \{0, 1\}$ with common prior $\mathbb{P}(S = 1) = p$. Consumers are identical except for their private signals $X$, where $X|S = 1 \sim F_H$ and $X|S = 0 \sim F_L$, and conditionally independent across individuals. The signals satisfy MLRP: $f(x) \equiv F_H'(x)/F_L'(x) \Rightarrow f'(x) > 0$. The additional assumption we make in the fraud case is that the entrepreneur has perfect private knowledge that the underlying state is low (i.e. $S = 0$), but this ugly truth is not known to the consumers.

**No ICO** When the platform launches in one period without ICO, the entrepreneur’s problem is mimic the innocent consumers and choose $C$ to maximize her payoff

$$C \times [p(1 - F_H(x^*)) + (1 - p)(1 - F_L(x^*))], \quad (25)$$

subject to

$$\mathbb{P}(S = 1|x^*) = \frac{pf(x^*)}{pf(x^*) + (1 - p)} = C \quad \text{(consumer IC)} \quad (26)$$
Denote $C^*$ as the solution to the maximization problem, then the entrepreneur’s payoff is

$$C^* \times (1 - F_L(x^*)), \quad (27)$$

**Introducing ICO** With ICO, the fraudulent entrepreneur could mislead the public by mimicking the innocent ones who sets $C_0$ and $C_1$ to maximize

$$C_0 \times [p(1 - F_H(x^*_0)) + (1 - p)(1 - F_L(x^*_0))] + pC_1 \times [1 - (1 - F_H(x^*_0))], \quad (28)$$

subject to

$$\frac{p \times f(x^*_0)}{p \times f(x^*_0) + (1 - p)} = C_0 \text{ (consumer IC)} \quad (29)$$
$$C_1 = 1 \quad (30)$$

To create the illusion that the project is of high type, the entrepreneur could offer side payments of at least $C_0$ to $F_L(x^*_0) - F_H(x^*_0)$ consumers (e.g. high influence early movers or celebrities) and lure them to join in the first stage. In this case, the entrepreneur’s payoff would be

$$C_0 \times (1 - F_L(x^*_0)) + C_1 \times [1 - (1 - F_H(x^*_0))], \quad (31)$$

Note that if the entrepreneur does not bribe early movers his payoff would be

$$C_0 \times (1 - F_L(x^*_0)), \quad (32)$$

which is strictly lower. Hence the fraudulent entrepreneur always has strict incentives to conduct compensated endorsement. If such compensation is not observed by follow-up consumers, these followers will be misled into a scam. This observation highlights the importance of disclosure requirement for ICO.
Note that the fraud problem is most severe when the consumer demography is not decentralized, because the manipulation can target only a small set of individual and prevents leakage (for example, celebrity endorsement).

3 Implications for policymakers as well as practitioners

Our model generates a mechanism by which an initial coin offering can play a valuable economic role for an early stage project. Here, we discuss implications of our findings for the recent debate over optimal regulatory treatment of ICOs.

First, the current debate over ICOs has been focusing on how existing securities laws should apply to regulating the new innovation. Our analysis instead inquires after the economic value creation of ICOs. We use social welfare as the criteria for assessing when ICOs should be restricted, and when they should be allowed. By distilling the multistage platform launch feature of many ICOs deals, our baseline model also provides a framework to help analyze other related regulatory issues in further development of the paper.

Second, we discuss the narrow question of whether coins sold in an ICO are securities like traditional debt or equity claims. In a strictly legal sense, this question is outside the scope of this paper, but in economic terms, our model provides a possibility that at least for many platform-like projects the answer is no. An ICO leads to cash inflows, likely at a time when the firm needs funds, yet that financing is not necessarily the purpose of the ICO. Rather, the structure could be an integrated part of the operational process of the platform, which leads to an efficient users participation outcome. Although the price of coins may increase endogenously over time, the ICO does not have to overcome any financial constraint that would prevent the issuance of a traditional equity security. To borrow words from Ryan Zurrer, Principal & Venture Partner of Polychain Capital, ICO is about fostering a community and “tokens act like rocket fuel for network effects”.

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The implications of this observation are twofold:

On the one hand, a token-issuing project should be very clear on how the newly minted tokens serve as an integrated element in the project. While qualified investors are free to speculate on the price path of an ICO, the fundamental purpose of an ICO is to induce efficient participation, not necessarily to provide a return on capital. Companies that ignore or muddy this distinction should be viewed skeptically by both investors and regulators.

On the other hand, companies that justify a proposed ICO in terms of the benefits described in this paper should be given leeway to execute them. This may require carving out a special regulatory exemption if ICO tokens do indeed fall under the existing legal definition of a security; our model justifies why such an exemption could have economic value, and why the resulting ICOs represent a valuable innovation. Of course, such exemption shall not exempt oversight of other dimensions of project risks. For example, requirement to disclose compensations for celebrity endorsement shall be enforced to prevent manipulation.

In contrast, ICO structure that do not explicitly appeal to any challenge should be discouraged or scrutinized: In our model, the specific challenge is a coordination failure arising from the network effect. While there is no way to prove that network effect is the only mechanism justifying an ICO, we view it likely the primary benefit from analyzing existing deals. We also note that any other proposed benefit of ICOs should be subject to a similar scrutiny as conducted in this paper before being accepted as a justification for a proposed offering. An ICO that fails this test is at higher risk of being the kind of pump-and-dump scheme that damages the integrity of financial markets and motivates securities regulation in the first place.

We can also use our model to consider optimal governance provisions in an ICO. In principle, the contract underlying the purchase of a token should include investor protections analogous to those in other product markets or financial markets. This topic has received relatively little attention in the press, but it is a potentially rich area for legal research, and
a few high profile examples illustrate the stakes and the challenges involved:

One important and unique governance challenge in an ICO is the possibility of devaluation: After selling coins to ICO participants, a company has every incentive to expropriate the value of those coins. A prominent and extreme example was Storjcoin, which simply began accepting forms of payment other than tokens for its platform.\textsuperscript{13} Our analysis then suggests that token sales should include contractual protection against this possibility. This conclusion is an important caution for potential token purchasers. It also provides another dimension along which regulators can judge proposed offerings, and along which high-quality offerings can separate themselves.

A more subtle way to accomplish this devaluation would be through dilution: If the company creates and sells more coins after the ICO, it effectively realizes seignorage revenue and expropriates some of the value of coins held by the ICO participants. This creates a difficult tradeoff, as new coin issuance may also be necessary to expand the network, which benefits existing participants via the network effect. ICO tokens should then include governance mechanisms controlling the expansion of the coin base via seasoned coin offerings, to allow for valuable network expansion while preventing opportunistic dilution.\textsuperscript{14}

Interestingly, blockchain technology provides a mechanism to address this issue. The technology allows the ICO seller to credibly pre-commit to an algorithm by which future coins will (or will not) be added to the current stock. This is interesting because it provides the first justification in our analysis of unique value of ICOs as crowdfunding on a blockchain, rather than simply being a form of store credit. Nevertheless, even after making use of this technology, it is likely that the ICO seller cannot fully specify the contract governing optimal coin issuance. Or the issuer may simply deploy a new smart contract as minting different

\textsuperscript{13}See https://safenetforum.org/t/storj-screws-their-ico-token-holders-big-time-by-accepting-direct-fiat-payments/12859.  
\textsuperscript{14}Note that the dilution problem for coins is worse than for equity, where the funds flowing into the firm’s balance sheet compensate old investors and offset the dilution effect.
but claimed to related tokens. In this case, regulators and investors should be aware of how residual control rights regarding the expansion of the coin base are allocated in the contract underlying the token sale.

A second set of governance problems arise from the moral hazard inherent in providing funds for any purpose to an early-stage company. Since risk is always inherent in pre-purchasing a product that does not yet exist, many commentators have highlighted the importance of “capped” ICOs to provide proper incentives for sellers to develop their products post-sale. An ICO cap is simply a requirement that the seller retain a stake in the ICO. This incentive mechanism works exactly like the retention of an equity stake in a public offering, and the straightforward implication is that sellers in an ICO should retain a stake in the tokens they sell, to align their incentives with coin purchasers in addition to equity owners of the firm. Again, investors regulators both can make use of this implication in their decisions about proposed ICOs.

Finally, our analysis illustrates one fundamental challenge for which there is no easy answer: A growing concern in the ICO community is that the increasing number of pre-sale rounds create opportunities for Ponzi-scheme ICOs, with each round paying off the previous round’s investors by pumping up the coin price long enough for the previous investors to exit. While this is a real concern, our analysis highlights that a dynamic sequencing of sale rounds is in fact essential to the mechanism by which the ICO overcomes the coordination problem inherent in a network setting. Thus, dynamic sales should not be prevented out of hand, but rather should be an area of close study for regulators and academics seeking to separate valuable from wasteful ICOs. In future revisions of the paper we plan to develop a balanced trade-off between the benefit of network effect/crowd wisdom and the cost of potential manipulation of fraudsters.

\footnote{The SEC has specifically warned that celebrity ICO endorsements could be illegal, see \url{https://www.coindesk.com/sec-celebrity-ico-endorsements-illegal/}.}
4 Conclusion

In this paper, we develop a framework to discuss optimal regulation toward initial coin offerings. Instead of following the conventional wisdom by focusing on whether tokens should be regarded as utility, security, or anything else, we take a economic perspective, and ask if and when token sales are value-creating or value-destroying from a social welfare perspective. In specific, we highlight two settings in which an ICO could create value: First, when projects feature network effects – that is, the surplus realized by any user increases in the size of the total user base. Second, when projects feature the “wisdom of the crowd” – that is, private signals about project value that are dispersed among its potential users. Both of these settings characterize recent tech startups, especially those that use ICOs. In either scenario, the ICO creates value by increasing the expected profit for the entrepreneur launching the project. Since these profits are necessary to overcome fixed costs, the ICO allows a greater range of socially-valuable projects to proceed.

Our findings have important implications for securities regulators concerned with the growing popularity of initial coin offerings. Because financial innovations are often accompanied by fraud that exploits holes in existing legal frameworks, a natural reaction is to ban the innovation completely. Indeed, many proposed ICOs likely do not serve important economic functions. But some do, and an ideal regulatory response would be to separate the wheat from the chaff by allowing them to proceed. Our model provides guidance in allowing that to happen. In ongoing work, we explicitly analyze traditional governance mechanisms in the setting of our model to provide further insights in these directions.
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Appendix

A Summary of International Regulatory Responses

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Regulator</th>
<th>Date</th>
<th>Regulatory Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>ASIC</td>
<td>Sept 2017</td>
<td>state that the legality of an ICO depends upon its detailed circumstances, and “in some cases, the ICO will only be subject to the general law and the Australian consumer laws”.¹⁶</td>
</tr>
<tr>
<td>Canada</td>
<td>Quebec Autorite des marches financiers</td>
<td>Sept 6, 2017</td>
<td>Exploring and sandbox certain deals¹⁷</td>
</tr>
<tr>
<td></td>
<td>Ontario Securities Commission</td>
<td>Oct 25, 2017</td>
<td>approve the ICO of TokenFunder, even after issuing warnings against ICOs earlier in the year.¹⁸</td>
</tr>
<tr>
<td>China</td>
<td>7 regulators</td>
<td>Sept 4, 2017</td>
<td>ban all ICOs within the People’s Republic of China¹⁹</td>
</tr>
<tr>
<td>France</td>
<td>Autorité des marchés financiers</td>
<td>by Oct 2017</td>
<td>working on regulations²⁰</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>Securities and Futures Commission</td>
<td>Sept 5, 2017</td>
<td>state that depending on the facts and circumstances, digital tokens may be subject to securities laws.²²</td>
</tr>
<tr>
<td>Japan</td>
<td>Financial Services Agency</td>
<td>Oct 30, 2017</td>
<td>clarify that ICOs may fall under the Payment Services Act and/or the Financial Instruments and Exchange Act depending on how they are structured.²³</td>
</tr>
</tbody>
</table>

¹⁸See here and here.
²⁰See https://www.coindesk.com/france-close-issuing-position-icos/.
²³See https://news.bitcoin.com/japans-financial-authority-initial-coin-offerings/
<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Regulator</th>
<th>Date</th>
<th>Regulatory Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isle of Man</td>
<td>Deptment of Economic Development</td>
<td>by Sept 6, 2017</td>
<td>has created a friendly regulatory framework[24]</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Financial Markets Authority</td>
<td>Oct 2017</td>
<td>release guidelines on the current regulatory environment in regards to ICOs.</td>
</tr>
<tr>
<td>Israel</td>
<td>Israel Securities Authority</td>
<td>Sept 1, 2017</td>
<td>announce plans to form a panel to regulate ICOs[25]</td>
</tr>
<tr>
<td>Russia</td>
<td>Vladimir Putin</td>
<td>Oct 2017</td>
<td>mandate new regulations including the application of securities laws to initial coin offerings (ICOs).[26]</td>
</tr>
<tr>
<td>Singapore</td>
<td>Monetary Authority of Singapore</td>
<td>Aug 1, 2017</td>
<td>indicate that tokens maybe regulated as securities depending on underlying basis and context[27]</td>
</tr>
<tr>
<td>South Korea</td>
<td>Financial Services Commission</td>
<td>Sept 28, 2017</td>
<td>ban all ICOs[29]</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Swiss Financial Market Supervisory Authority</td>
<td>Sept 29, 2017</td>
<td>clarify ICOs not regulated under Swiss law, but “due to the underlying purpose and specific characteristics of ICOs, various links to current regulatory law may exist”. Also announce investigations of an unspecified number of coin offerings.[30]</td>
</tr>
<tr>
<td>UAE (Abu Dhabi Global Market)</td>
<td>Financial Services Regulatory Authority</td>
<td>Oct 9, 2017</td>
<td>describe ICOs as a “novel and potentially more cost-effective way of raising funds for companies and projects, argue against a “one size fits all” approach, and indicate regulations on a case-by-case basis.[31]</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Financial Conduct Authority</td>
<td>Sept 12, 2017</td>
<td>issue consumer warning[32]</td>
</tr>
</tbody>
</table>

### Jurisdiction | Regulator | Date | Regulatory Responses
--- | --- | --- | ---
USA | SEC | July 2017 | indicate potential application of federal securities laws, determined on a case-by-case basis.  
Sept 2017 | charged Maksim Zaslavskiy for fraud in connection with the ICOs for RECoin and DRC World.  
Oct 2017 | rule that celebrity ICO endorsements must disclose the amount of any compensation.

## B Discrete number of consumers

The assumption of a continuum of consumers in our main analysis illustrates our main ideas in an elegant and concise manner. It does, however, generate one unrealistic feature: the entrepreneur in our model extracts all the social surplus created by the platform, leaving zero to the consumers. In this section, we show that when we adopt the more realistic assumption of a discrete number of consumers, this problem no longer exists, while our main conclusions remain intact. All assumptions are exactly the same as in Section 2, except that instead of a unit continuum of consumers, there is a discrete number $N$ of them.

### B.1 The entrepreneur’s problem without an ICO

Given a price $C$, each consumer $i$ follows the same cutoff strategy as in Section 2. The entrepreneur’s expected profit is different from that section, because we now integrate over a discrete instead of a continuous distribution: Let $M$ represent the number of consumers who join the platform (i.e. those with signals higher than $x^*$). Then for $m \in \{0, 1, 2, ..., N\}$,

$$P(M = m) = \binom{N}{m}(1 - F_S(x^*))^m F_S^N-m(x^*)$$

Hence, we obtain the entrepreneur’s problem below:

**The entrepreneur’s problem**  

The entrepreneur chooses $C$ to maximize expected payoff

$$p \sum_{m=0}^{N} Cm \binom{N}{m} (1 - F_H(x^*))^m F_H^{N-m}(x^*) + (1-p) \sum_{m=0}^{N} Cm \binom{N}{m} (1 - F_L(x^*))^m F_L^{N-m}(x^*),$$

35 See https://www.coindesk.com/sec-celebrity-ico-endorsements-illegal/
subject to
\[
\frac{pf(x^*)}{pf(x^*) + (1 - p)} = C \quad \text{(consumer IC)}
\] (35)

**B.2 The entrepreneur’s problem with an ICO**

Denote \( m \) as the number of consumers who participate in ICO (that is, join at time zero) and \( n \) as the number who participate in the actual platform launch (that is, join at time one). Because \( m \) is indicative of the underlying state \( S \in \{H, L\} \), at the second stage when the platform is actually launched, all players will make decisions with the additional signal \( m \). A consumer will participate if and only if

\[
\mathbb{P}(S = 1|X, m) \geq C_1,
\] (36)

where

\[
\mathbb{P}(S = 1|X, m) = \frac{p\mathbb{P}(X, m|S = 1)}{p\mathbb{P}(X, m|S = 1) + (1 - p)p\mathbb{P}(X, m|S = 0)} = \frac{p\mathbb{P}(X|S = 1)p(m|X, S = 1)}{p\mathbb{P}(X|S = 1)p(m|X, S = 1) + (1 - p)p\mathbb{P}(X|S = 0)p(m|X, S = 0)}
\] (37)

Denote \( x_0^* \) as the signal cutoff above which the consumer will participate in the ICO, then when \( X < x_0^* \) (i.e. if he has not participated in the ICO), we have (37)=

\[
\frac{pf(X)(N-1)}{m}{(1 - F_H(x_0^*))^{m}(1 - F_H(x_0^*))^{N-m-1}} + (1 - p)(\frac{N-1}{m})^m(1 - F_H(x_0^*))^{m}(1 - F_H(x_0^*))^{N-m-1}
\]

\[
= \frac{pf(X)(1 - F_H(x_0^*))^m(1 - F_H(x_0^*))^N}{{m}(1 - F_H(x_0^*))^{N-m-1}} + (1 - p)(1 - F_H(x_0^*))^m(1 - F_H(x_0^*))^{N-m-1}
\] (38)

Hence a consumer who has not participated in the ICO (i.e. \( X < x_0^* \)) will participate in the second stage if and only if his signal is higher than the cutoff \( x_1^* \) given by

\[
\frac{pf(x_1^*(m))(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*)}{pf(x_1^*(m))(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1 - p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)} = C_1(m)
\] (39)

Notice that for any given \( x_0^* \) and \( m \) the entrepreneur always set \( C_1(m) \) low enough to ensure \( x_1^*(m) < x_0^* \), because otherwise she earns zero in the second stage. In another word, the entrepreneur faces a Coase conjecture and any promises to keep a high \( C_1(m) \) is not credible.

A consumer participates in the ICO if and only if

\[
\mathbb{P}(S = 1|X) \geq C_0
\] (40)
i.e. she expects no loss from participating in the ICO, and

\[ P(S = 1 | X) - C_0 \geq E_m [P(S = 1 | X, m) - C_1(m) | X], \]  

(41)
i.e. she is better off participating in the ICO than waiting.

Since \( E_m [P(S = 1 | X, m) - C_1(m) | X] = \)

\[ P(S = 1 | X) - \sum_{m=0}^{N-1} \left\{ C_1(m) \left( \binom{N-1}{m} \frac{pf(X)(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)}{pf(x_0^*) + (1-p)} \right) \right\} \geq C_0 \]

the two conditions (40) and (41) are expanded to

\[ \frac{p_f(x_0^*)}{p_f(x_0^*) + (1-p)} \geq C_0 \]

(42)

\[ \sum_{m=0}^{N-1} \left\{ C_1(m) \cdot \binom{N-1}{m} \cdot \frac{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)}{p_f(x_0^*) + (1-p)} \right\} \geq C_0 \]

(43)

Since \( \forall m, x_1^*(m) \leq x_0^* \), by (39)

\[ C_1(m) \leq \frac{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*)}{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)}, \]

(44)
hence the left hand side of (43) ≤

\[ \sum_{m=0}^{N-1} \left\{ \frac{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*)}{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)} \cdot \binom{N-1}{m} \cdot \frac{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)}{p_f(x_0^*) + (1-p)} \right\} \]

= \sum_{m=0}^{N-1} \left\{ \frac{p_f(x_0^*) (1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*)}{p_f(x_0^*) + (1-p)} \cdot \binom{N-1}{m} \right\} = \frac{p_f(x_0^*)}{p_f(x_0^*) + (1-p)}. \]

(45)
Hence we do not need to consider (42) as it is absorbed by (43). In sum, with the introduction of ICO, the entrepreneur’s problem becomes the following:
The entrepreneur’s problem with ICO  The entrepreneur sets $C_0$ and $C_1(m), m \in \{0, 1, 2, ..., N - 1\}$ to maximize his profit (before the fixed cost $K$)

$$
Np \sum_{m=0}^{N-1} C_1(m) \left( F_H(x_0^*) - F_H(x_1^*(m)) \right) \binom{N-1}{m} \left( 1 - F_H(x_0^*) \right)^m F_H^{N-m-1}(x_0^*) \\
+ N(1-p) \sum_{m=0}^{N-1} C_1(m) \left( F_L(x_0^*) - F_L(x_1^*(m)) \right) \binom{N-1}{m} \left( 1 - F_L(x_0^*) \right)^m F_L^{N-m-1}(x_0^*) \\
+ NC_0 \times [p(1 - F_H(x_0^*)) + (1-p)(1 - F_L(x_0^*))]
$$

subject to

1. conditional on $x_0^*, \forall m \in \{0, 1, 2, ..., N - 1\}$ $x_1^*(m)$ is given by

$$
\frac{pf(x_1^*(m))(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*)}{pf(x_1^*(m))(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)} = C_1(m)
$$

(47)

2. $x_0^*$ is given by

$$
\sum_{m=0}^{N-1} \left[ C_1(m) \binom{N-1}{m} \frac{pf(x_0^*)(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)}{pf(x_0^*) + (1-p)} \right] = C_0
$$

(48)

Analysis of the entrepreneur’s problem  The entrepreneur’s payoff with ICO is alternatively given by

$$\arg\max_{\{x_0^*, x_1^*(m)\}, N} \sum_{m=0}^{N-1} \left( N - 1 \right) \frac{pf(x_1^*(m))(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*)}{pf(x_1^*(m))(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)} \cdot \left\{ p \left( F_H(x_0^*) - F_H(x_1^*(m)) \right) \left( 1 - F_H(x_0^*) \right)^m F_H^{N-m-1}(x_0^*) + (1-p) \left( F_L(x_0^*) - F_L(x_1^*(m)) \right) \left( 1 - F_L(x_0^*) \right)^m F_L^{N-m-1}(x_0^*) \\
+ \frac{pf(x_0^*)(1 - F_H(x_0^*))^m F_H^{N-m-1}(x_0^*) + (1-p)(1 - F_L(x_0^*))^m F_L^{N-m-1}(x_0^*)}{pf(x_0^*) + (1-p)} \left[ p(1 - F_H(x_0^*)) + (1-p)(1 - F_L(x_0^*)) \right] \right\}
$$

(49)

In comparison, the entrepreneur’s payoff without ICO is

$$\sum_{m=0}^{N} \frac{pf(x^*)}{pf(x^*) + (1-p)} m \binom{N}{m} \left[ p(1 - F_H(x^*))^m F_H^{N-m}(x^*) + (1-p)(1 - F_L(x^*))^m F_L^{N-m}(x^*) \right] \\
= N \frac{pf(x^*)}{pf(x^*) + (1-p)} \left[ p(1 - F_H(x^*)) + (1-p)(1 - F_L(x^*)) \right],
$$

(50)
Comparing the entrepreneur’s payoff with or without ICO, we get the following main result:

**Theorem B.1.** The entrepreneur achieves greater expected profit with than without the ICO.

**Proof.** (49) is no smaller than when \( x_0^* \) is forcibly set to 1, which is equal to

\[
\arg\max_{\{x_1(0)\}} N \frac{pf(x_1^*(0))}{pf(x_1^*(0)) + (1-p)} \cdot [p(1-F_H(x_1^*(0))) + (1-p)(1-F_L(x_1^*(0)))] = (50)
\]

Hence introducing ICO always improves the entrepreneur’s payoff.

**C Comparison with IPO**

We further calculate the payoff to the entrepreneur when he conducts an IPO, or selling shares of claims to the project’s future cash flow. We first drop the critical mass constraint and focus only on the wisdom of the crowd channel. Before the project launches the entrepreneur chooses to sell a proportion \( \lambda \) of the project’s potential profit. When the project is launched, the entrepreneur price the service at the price of \( C' \). \( C' \) may be dependent on the IPO outcome if it conveys additional information to the entrepreneur and the consumers (specifically, the price \( P \) for the \( \lambda \) shares and \( \mu \), the number (measure) of IPO volume demanded).

We assert and later verify that \( P \) and \( \mu \) perfectly reveals the state \( S \). When the state is revealed to be \( H \), the entrepreneur can charge 1 to all consumers and hence the eventual payoff to investors holding \( \lambda \) of the firm is \( \lambda \). Similarly, when the state is revealed to be \( L \), the entrepreneur cannot sell the service to anyone and hence the eventual payoff to investors holding \( \lambda \) of the firm is 0. Since from the entrepreneur’s perspective the high state and happens with probability \( p \), the \( \lambda \) shares will be priced no lower than \( p\lambda \).

For a given \( P \), an investor with private signal \( X \) would participate in the IPO if and only if \( \lambda \frac{pf(x_0^*)}{pf(x_0^*)+1-p} = P \). By market clearing we have that \( \lambda = 1-F_S(x_0^*) \). Hence the entrepreneur’s expected payoff is

\[
P + p(1-\lambda) = [p(1-F_H(x_0^*)) + (1-p)(1-F_L(x_0^*))] \frac{pf(x_0^*)}{pf(x_0^*) + 1-p} + pF_H(x_0^*) \quad (51)
\]

In comparison, with ICO the entrepreneur’s payoff is

\[
\frac{pf(x_1^*)}{pf(x_1^*) + 1-p} (1-F(x_1^*) + pF_H(x_1^*)) \quad (52)
\]

**D Private value versus private information**

There is a state of nature \( S \in \{H,L\} \). Private valuations \( X_i \) are drawn from \( F_s \) where \( F_H'(x)/F_L'(x) > 0 \). If at least \( \alpha \) consumers participate in the platform by the end of the
game, then each participant gets $X_i$; otherwise they get nothing. Note that we do not assume payoff is zero in state $L$ (we could, but we don’t need to).

D.1 Without the ICO

A consumer joins the platform if and only if

$$X_i \times \Pr(\text{at least } \alpha \text{ consumers join}| X_i) \geq C$$

As in the core analysis, let’s say the entrepreneur will always price to satisfy the constraint, so we can say consumers just participate based on $X_i \geq C$ and the critical-mass constraint shows up as a constraint on the entrepreneur’s problem that must hold state-by-state. Then aggregate expected participation is just $1 - F(X_i^*)$ where $F = pF_H + (1-p)F_L$.

The consumer’s problem: given $C$, participate iff private value $X \geq x_0^*$ ($X$ not only directly affects payoff, but also helps infer the state $S$)

1. $C$ is so high that the $\alpha$ constraint is expected to be violated $\forall S$

   $\Rightarrow$ entrepreneur will avoid this zero-revenue case

2. the $\alpha$ constraint is satisfied when $S = H$ but violated when $S = L$

   $$\begin{cases} 
   x_0^* \Pr(S = H|x_0^*) = C \\
   1 - F_H(x_0^*) \geq \alpha \\
   1 - F_L(x_0^*) < \alpha 
   \end{cases}$$

3. $C$ is so low that the $\alpha$ constraint is expected to be satisfied $\forall S$

   $$\begin{cases} 
   x_0^* = C \\
   1 - F_L(x_0^*) \geq \alpha 
   \end{cases}$$

   Then the entrepreneur solves the monopolist’s problem subject to that constraint,

   $$\max_C C \times (1 - F(C)) \quad \text{subject to} \quad 1 - F_L(C) \geq \alpha$$

   The constraint pins down $C = F_L^{-1}(1 - \alpha)$. If the entrepreneur raises the price above this point, he won’t attract a critical mass. If he sets it any lower, he is leaving money on the table. Total revenue is $\alpha \times F_L^{-1}(1 - \alpha)$.

The entrepreneur’s problem: choose $C$ to maximize her payoff

$$C \times [p(1 - F_H(x_0^*)) + (1 - p)(1 - F_L(x_0^*))], \quad (54)$$
subject to either

\[
\frac{pf(x_0^*)}{pf(x_0^*) + (1-p)} x_0^* = C \quad \text{(consumer IC)} \tag{55}
\]

\[
1 - F_H(x_0^*) \geq \alpha > 1 - F_L(x_0^*) \quad \text{(critical mass)} \tag{56}
\]

or

\[
x_0^* = C \quad \text{(consumer IC)} \tag{57}
\]

\[
1 - F_L(x_0^*) \geq \alpha \quad \text{(critical mass)} \tag{58}
\]

We can analyze the shadow value of relaxing this constraint by attaching multiplier $\lambda$. The first-order condition is $C + \lambda \times F'_L(C) = m_F(C)$. In the unconstrained problem the FOC would be $C = m_F(C)$, so this shows that $C$ is lower due to the constraint.

### D.2 With the ICO

Now we allow agents to buy in either at time zero or at time 1. The entrepreneur sets two prices $C_0, C_1$. At each date, consumers follow cutoff strategies $X_0^*, X_1^*$, participating in the platform if their private valuations are above these cutoffs. Solve backwards:

At time 1, everyone knows total participation $\mu(C_0)$ from time zero. This perfectly reveals the state of nature, and the entrepreneur then extracts as much surplus as possible from the remaining agents by monopolistically pricing the platform. The participation decision is just $X_i \geq C_1$, so that $X_1^* = C_1$. Thus the entrepreneur’s time-1 problem (state by state) is

\[
\max_{C_1} C_1 \times (F_s(X_0^*) - F_s(C_1)) \quad \text{subject to} \quad 1 - F_s(C_1) \geq \alpha
\]

(We will also show that $C_1 < X_0^*$, which is why $X_0^*$ does not appear in the constraint.) The solution to the time-1 problem is then similar to the previous subsection. The price is given by $C_1 = F_{s}^{-1}(1 - \alpha)$. The state-by-state first-order condition is $C_1 + \lambda = \frac{F_s(X_0^*) - F_s(C_1)}{F'_s(C_1)}$. Time-1 revenue in state $s$ is $(\alpha - (1 - F_s(X_0^*))) \times F_{s}^{-1}(1 - \alpha)$.

Now move back to the time-zero problem: Consumers participate if $X_i \geq C_0$ and also $E[C_1|X_i] \geq C_0$.

\[
\max_{C_0} E\left[C_0 \times (1 - F_s(X_0^*)) + C_1 \times (\alpha - (1 - F_s(X_0^*))\right]
\]

We can substitute in $C_1 = F_{s}(1 - \alpha)$. Note that the critical-mass constraint is not imposed at time zero but shows up implicitly through the solution to the time-1 problem.

This yields the first-order condition

\[
1 - F(X_0^*) = F'(X_0^*) \times (C_0 - E[F_{s}^{-1}(1 - \alpha)]) \times \frac{dX_0^*}{dC_0} \tag{59}
\]
We can now prove that revenue is higher with the ICO than without it:

Total revenue without the ICO is

\[ \alpha \times F_L^{-1}(1 - \alpha) \]

Total revenue with the ICO is

\[ C_0 \times (1 - F(X_0^*)) + \mathbb{E}[F_s^{-1}(1 - \alpha)] \times (\alpha - (1 - F(X_0^*))) \]

Rearrange this to

\[ \alpha \times \mathbb{E}[F_s^{-1}(1 - \alpha)] + (1 - F(X_0^*)) \times (C_0 - \mathbb{E}[F_s^{-1}(1 - \alpha)]) \]

First term: Note that \( F_H^{-1}(1 - \alpha) > F_L^{-1}(1 - \alpha) \), so \( \alpha \times \mathbb{E}[F_s^{-1}(1 - \alpha)] > \alpha \times F_L^{-1}(1 - \alpha) \).

Second term: We just need to show that this term is nonnegative. This comes down to showing \( C_0 \geq \mathbb{E}[F_s^{-1}(1 - \alpha)] \). Look at the first-order condition (59): The LHS is strictly positive if we assume \( X \) is distributed on a continuum (otherwise it is weakly positive). Both of the derivatives \( F'(X_0^*) \) and \( \frac{dX_0^*}{dC_0} \) are also strictly positive. So for the equation to hold, we must have \( C_0 > \mathbb{E}[F_s^{-1}(1 - \alpha)] = \mathbb{E}[C_1] \).

Intuition:

- The core driver of the result is the ordering \( C < \mathbb{E}[C_1] < C_0 \), where \( C \) is the non-ICO price of the platform. In the ICO, all of the \( \alpha \) mass of eventual participants pay at least \( C_1 \), so in expectation revenue is already higher due to the first part of the inequality. Some participants pay \( C_0 \), so this creates even more expected profit for the entrepreneur compared to the non-ICO case.

- The first inequality \( C < \mathbb{E}[C_1] \) holds because there is a possibility that we end up in state \( H \), in which case the entrepreneur can charge a higher price, and if we end up in state \( L \) he is no worse off since the constraint had to hold state-by-state in the non-ICO problem. In other words, there is option value in deferring the pricing decision to a later date when we know more about the state of the world.

- The second inequality \( \mathbb{E}[C_1] < C_0 \) holds because otherwise the entrepreneur is behaving suboptimally: As long as someone participates in the ICO so the state is revealed, \( C_1 \) is fixed at \( F_s(1 - \alpha) \). The positive participation in the ICO gives the entrepreneur the opportunity for price discrimination, and it would be irrational to charge any less than \( \mathbb{E}[C_1] \).

- Why would anyone buy into the ICO if the unconditional expectation is that the price will fall? Answer: They have high private valuations, which makes them think that the state is likely to be \( H \) so others will also have high valuations. Thus their conditional expectation given their high private valuations is that the price will rise to \( F_H^{-1}(1 - \alpha) > C_0 \).
The entrepreneur’s problem: choose $C_0$ and $C_1$ to maximize

$$C_0 \times [p(1 - F_H(x_0^*)) + (1 - p)(1 - F_L(x_0^*))] +$$
$$pC_1 \times (F_H(x_0^*) - F_H(x_{1H}^*)) + (1 - p)(1 - F_L(x_0^*) - F_L(x_{1L}^*)),$$

(60)

subject to

$$x_{1H}^* = C_1, \ x_{1H}^* \leq x_0^*, \text{ and } 1 - F_H(x_{1H}^*) \geq \alpha$$

(61)

$$x_{1L}^* = C_1, \ x_{1L}^* \leq x_0^*, \text{ and } 1 - F_L(x_{1L}^*) \geq \alpha$$

(62)

$$\frac{pf(x_0^*)C_1H + (1 - p)C_1L}{pf(x_0^*) + 1 - p} \geq C_0$$

(63)

It is easy to see that when the $\alpha$ constraint is satisfied in both the $H$ and $L$ state without ICO, introducing ICO improves the entrepreneur’s payoff

- simply set $C_0 = C_1 = C_1L = C$

What about other cases? Does introducing ICO help?

- easy to visualize that if the $L$-state full demand curve is above the weighted state lower demand curve, ICO increases the entrepreneur’s payoff.

D.3 Discussion: Comparison with IPO

What does the ICO accomplish that the IPO could not? In either case, the goal is information aggregation, revealing the distribution of consumers’ private valuations to the entrepreneur, and allowing him to price more aggressively while respecting the critical-mass constraint. The ICO reveals consumers’ private valuations through their participation decisions. The IPO would instead reveal consumers’ posterior probabilities of the state being $H$, based on their willingness to invest in the platform. In our model, the information thus revealed is the same, but the ICO is a superior mechanism as it raises a larger amount of funds for the entrepreneur. One could create a unique advantage to the IPO by adding a continuum of speculators who are informed about another dimension of project success probability.

D.4 Alternative setup

A risk-neutral entrepreneur incurs a fixed cost $K$ to launch a platform

- After $K$, the entrepreneur charges a monopolistic per-capita cost $C$ to a unit continuum of consumers for access to the platform

The more the merrier

- surplus from the platform increases with the number of participants $\alpha$
An individual consumer’s payoff is:

\[
\begin{cases}
  0, & \text{if he does not participate} \\
  \alpha + X - C, & \text{if he participates and there are } \alpha \text{ total participants}
\end{cases}
\]

- private value \( X \sim F_S \) where \( S \in \{H, L\} \) with \( \mathbb{P}(S = H) = p \)
- MLRP: \( f(x) \equiv F_H'(x)/F_L'(x) \Rightarrow f'(x) > 0 \)
- \( X \) conditionally independent across users

Platform launch with network externality without ICO In the private information case, consumers do not care about the \( \alpha \) constraint when \( S = L \) because she gets 0 anyway. No longer true here.

**The consumer’s problem:** given \( C \), participate iff private value \( X \geq x_0^* \)

- \( X \) not only directly affects payoff, but also helps infer the state \( S \)
- \( (1 - F_H(x_0^*))\mathbb{P}(S = H|x_0^*) + (1 - F_L(x_0^*))\mathbb{P}(S = L|x_0^*) + x_0^* = C \)

**The entrepreneur’s problem:** choose \( C \) to maximize her payoff

\[
C \times [p(1 - F_H(x_0^*)) + (1 - p)(1 - F_L(x_0^*))],
\]

subject to

\[
\frac{pf(x_0^*)(1 - F_H(x_0^*)) + (1 - p)(1 - F_L(x_0^*))}{pf(x_0^*) + 1 - p} + x_0^* = C
\]

When introducing ICO: **The entrepreneur’s problem:** choose \( C_0 \) and \( C_{1S} \) to maximize

\[
C_0 \times [p(1 - F_H(x_0^*)) + (1 - p)(1 - F_L(x_0^*))] + \\
pC_{1H} \times (F_H(x_0^*) - F_H(x_{1H}^*)) + (1 - p)C_{1L} \times (F_L(x_0^*) - F_L(x_{1L}^*)),
\]

subject to

\[
1 - F_H(x_{1H}^*) + x_{1H}^* = C_{1H}, \ x_{1H}^* \leq x_0^* \quad (67)
\]
\[
1 - F_L(x_{1L}^*) + x_{1L}^* = C_{1L}, \ x_{1L}^* \leq x_0^* \quad (68)
\]
\[
\frac{pf(x_0^*)C_{1H} + (1-p)C_{1L}}{pf(x_0^*) + 1 - p} \geq C_0 \quad (69)
\]

Does introducing ICO increase the entrepreneur’s payoff?

**Theorem D.1** (Sufficient conditions for ICO to boost profit). The entrepreneur’s payoff is higher with ICO if

1. private value distributions are adequately dispersed: \( \forall S \in \{H, L\}, 1 - f_S(x) > 0 \)
2. \( f_H \) and \( f_L \) are adequately separated: with \( f(x) = \frac{f_H(x)}{f_S(x)} \) we have \( \lim_{x \to \bar{x}} f(x) = \infty \), where \( \bar{x} \) is the supremum of the support of \( x \).

Proof. Condition 1 guarantees that the first equations within (67) and (67), respectively, uniquely pin down \( x_1^H \) and \( x_1^L \) for given \( C_1^H \) and \( C_1^L \). Choose \( C_1^H \) and \( C_1^L \) that maximizes \( C_1^H (1 - F_H(x_1^H)) \) and \( C_1^L (1 - F_L(x_1^L)) \), and set \( C_0 \) to be \( C_1^H - \epsilon \) for some small \( \epsilon \). Condition 2 indicates that when \( \epsilon \) is small enough \( x_0^* \geq x_1^H \) and (68) is satisfied. Furthermore as long as \( \epsilon \) is small enough, payoff under ICO is larger than that without ICO. \( \square \)

E Digesting the entrepreneur’s problem without ICO

Attaching multiplier \( \lambda \) to the constraint (56), the first-order condition for the problem is

\[
1 - F_H(x_0^*) = (C + \lambda) \times F_H'(x_0^*) \times \frac{dx_0^*}{dC} \tag{70}
\]

When a mass strictly greater than \( \alpha \) participates, then \( \lambda = 0 \) and we have a standard monopolist’s problem: The marginal benefit of increasing \( C \) is equal to the mass of inframarginal consumers, \( 1 - F_H(x_0^*) \), who each pay marginally more. The marginal cost is the change in the participation threshold, \( \frac{dx_0^*}{dC} \), multiplied by the revenue obtained from consumers just at that threshold, \( C \times F_H'(x_0^*) \). The first-order condition captures the entrepreneur balancing these two effects against each other.

In contrast, \( \lambda > 0 \) if and only if the mass of consumers participating is exactly \( \alpha \). In this case, the entrepreneur gives up some rents to induce sufficient participation. In other words, the problem only differs from the standard monopolist’s problem to the extent that the entrepreneur would optimally induce participation by a mass smaller than \( \alpha \) in the unconstrained problem.

We can work out explicitly the condition for this to be true: \( \lambda > 0 \) if and only if the entrepreneur would induce \( 1 - F_H(x_0^*) < \alpha \) in the unconstrained problem, and this is equivalent to \( x_0^* > F^{-1}_H(1 - \alpha) \). For this to be optimal, it must be that, when \( x_0^* = F^{-1}_H(1 - \alpha) \) so that exactly \( \alpha \) customers participate, the marginal benefit of increasing \( C \) (and thus decreasing participation below \( \alpha \)) is greater than the marginal cost,

\[
\alpha > \left( C \times F_H'(x_0^*) \times \frac{dx_0^*}{dC} \right) \bigg|_{x_0^* = F^{-1}_H(1 - \alpha)} \tag{71}
\]

Intuitively, for the entrepreneur to want to induce participation of less than \( \alpha \) in the unconstrained problem, it must be that the required mass of participants \( \alpha \) is greater than the rate at which marginal revenue falls in response to an increase in price when exactly \( \alpha \) consumers participate.

To state this condition in terms of model primitives, we can implicitly differentiate (55) to get

\[
\frac{dx_0^*}{dC} = \frac{[p f(x_0^*) + (1 - p)]^2}{(1 - p) \times p f'(x_0^*)} \tag{72}
\]
which is positive due to the MLRP assumption $f' > 0$. Intuitively, when the entrepreneur charges more for the platform, this induces a higher minimum signal $x^*_0$ for agents to be willing to participate. Using also the fact that $C = \frac{pf(x^*_0)}{pf(x^*_0) + (1 - p)}$, the bound on $\alpha$ in terms of model primitives is

$$\alpha > \left( F'_H(x^*_0) \times \frac{pf(x^*_0)}{pf(x^*_0) + (1 - p)} \times \frac{[pf(x^*_0) + (1 - p)]^2}{(1 - p) \times pf'(x^*_0)} \right) \bigg|_{x^*_0 = F_H^{-1}(1 - \alpha)}$$  \hspace{1cm} (73)

which simplifies to the (strictly positive) lower bound,

$$\alpha > \left( F'_H(x^*_0) \times \frac{f(x^*_0)}{f'(x^*_0)} \times \left( \frac{p}{1 - p} f(x^*_0) + 1 \right) \right) \bigg|_{x^*_0 = F_H^{-1}(1 - \alpha)}$$ \hspace{1cm} (74)

(It seems like there should be some way to simplify this, but I’m not sure how.)

An equivalent way to state this is

$$\alpha > \left( \frac{d}{dx^*_0} \ln f(x^*_0) \times \left( \frac{p}{1 - p} f(x^*_0) + 1 \right) \right) \bigg|_{x^*_0 = F_H^{-1}(1 - \alpha)}$$ \hspace{1cm} (75)

and I think $\frac{d}{dx^*_0} \ln f(x^*_0)$ might have a deeper interpretation in terms of information theory.

Given a value of $\alpha$, this condition contains two assumptions:

First, for the problem to be interesting, the prior probability $p$ must not be too large. The intuition is that, if $p$ is large, consumers are likely to participate regardless of their signals, and inducing the minimum fraction $\alpha$ will not be an issue. Only if $p$ is relatively small will the constraint bind, requiring the entrepreneur to give up rents (and ultimately creating a role for the ICO).

The second assumption is a functional-form assumption on the higher-order local behavior of $F_H$ and $F_L$ at $F_H^{-1}(1 - \alpha)$. Intuitively, it requires that $F_H$ not be too sharply increasing where it equals $1 - \alpha$. This is most clearly seen by letting $p \to 0$ to shut down the prior effect. Then the lower bound on $\alpha$ becomes

$$\alpha > \left( \frac{F'_H(x^*_0)}{F_H'(x^*_0)} - \frac{F'_L(x^*_0)}{F_L'(x^*_0)} \right) \bigg|_{x^*_0 = F_H^{-1}(1 - \alpha)}$$ \hspace{1cm} (75)

or equivalently

$$\alpha > \left( \frac{d}{dx^*_0} \ln f(x^*_0) \right) \bigg|_{x^*_0 = F_H^{-1}(1 - \alpha)}$$ \hspace{1cm} (76)

The numerator measures the mass of consumers who leave the platform in response to a marginal increase in the cutoff signal $x^*_0$, when exactly $\alpha$ consumers participate in the platform. The denominator captures the marginal informativeness of signals near $x^*_0$. This is a measure of consumers’ willingness to pay: When the signal is very informative, the cutoff $x^*_0$ is not very sensitive to shifts in price. The entrepreneur can then increase the price more aggressively in this region without driving consumers away. (This can be seen from the fact
that $f'$ appeared in the denominator of $\frac{d\pi^*}{dC}$ above.) On the other hand, when the signal is uninformative, consumers are more sensitive to price.

Thus, for the participation constraint to bind, the mass of the consumers at the cutoff signal must not be too large relative to the informativeness of that cutoff signal, when exactly $\alpha$ consumers participate in the platform. If, instead, the mass of consumers at the cutoff is large, then the entrepreneur lowers price in order to attract them. Then participation exceeds $\alpha$ even without the constraint, and are are no rents left to consumers, and thus no role for the ICO. If the cutoff signal is also uninformative, this amplifies the rate at which consumers join in response to the price decrease.

We assume that (74) holds for the rest of the analysis, so that $\lambda > 0$. This means rents are left to the consumers. Consumers with signals above the optimal cutoff from the unconstrained problem pay a lower price than they would without the constraint. Also due to this lower price, consumers with signals between the optimal cutoffs from the constrained and unconstrained problems find it optimal to participate in the platform, where otherwise they would not.

But then the optimal mechanism would involve an IPO for those speculators, and and ICO for the participants; it would not cause the entrepreneur to abandon the ICO.