

Optimal Platform Financing with Tokens:

Asymmetric Information and Investors as Users

Nianzu Xiong

Department of Economics, University of Oxford

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Abstract

A platform can raise capital with debt, outside equity, or tokens, and the buyers of tokens become its users. I study this choice when the entrepreneur privately knows the platform's prospects. Under any investor belief, a contract affects the entrepreneur only through two numbers: what investors receive if the platform fails, which determines how much of the contract is mispriced, and how many investors become users. Debt is best on the first margin and tokens on the second; outside equity is dominated on both. Under pooled beliefs the high type therefore issues safe debt first, then tokens, and risky debt only once token capacity is exhausted. Airdrops are dominated by sales unless sales already cover the investment. In the baseline, the low type sells more tokens than the high type in every separating equilibrium, so a larger token sale is bad news. Refinement selects least-cost separation for small projects, pooling for large projects, and semi-separation in between. Token sales become good news when users are costly to serve and good platforms retain users better. Issuance costs cap token sales at an interior level, and a retention role for tokens can put them ahead of debt.

JEL: D82, G23, G32, L14. **Keywords:** pecking order, security design, tokens, initial coin offerings, network effects, signaling.

1 Introduction

A platform's value depends on its users. When a platform raises capital by selling tokens, the buyers are often the users: a token is at once a financial claim and a means of access. This distinguishes tokens from the securities of standard corporate finance. A firm that issues debt or equity sells a claim on cash flows that are, at the time of issue, largely given. A platform that issues tokens sells a claim on value that the sale itself helps to create.

This paper asks how that feature interacts with the central friction in corporate finance, asymmetric information between insiders and outside investors. The classic answer, due to [Myers and Majluf \(1984\)](#) and [Myers \(1984\)](#), is a pecking order: securities whose value is least sensitive to the insider's private information are least mispriced and are issued first, so safe debt precedes risky debt, which precedes equity. Tokens do not fit this order, because they carry a benefit that no other outside claim carries. I ask where tokens enter the pecking order, what a token sale reveals about the issuer, and which of these conclusions survive equilibrium refinement.

Two margins. The analysis rests on ranking securities along two margins. The first is the classical one. A high-quality entrepreneur whose securities are priced at average quality sells them below their value, and the loss *dilutes* her retained claim. Debt limits dilution: a claim that pays the same in every state cannot be mispriced, and a claim that pays mostly in the failure state is mispriced little. The second margin is specific to platforms. A token creates *adoption*: its buyer becomes a user, which raises the value of the platform and therefore of the tokens themselves. Outside equity does poorly on both margins. As a residual claim it is the most sensitive to private information, and it brings no users. [Table 1](#) summarizes.

Table 1: Two margins of security choice

Security	Dilution of the high type's claim	Creates users
Safe debt ($D \leq K$)	None	No
Risky debt ($D > K$)	On success-state payoffs	No
Outside equity	At least as much as debt raising the same amount	No
Tokens	On success-state payoffs	Yes

Two features of the table drive the security-design results. Debt and tokens each do best on one margin, so the optimal contract combines them. And once safe debt capacity is used up, every remaining outside claim pays only in the success state and is mispriced at the same rate. The claims are then tied on the dilution margin, and the adoption margin breaks the tie in favor of tokens. Outside equity is never strictly optimal.

Security design. An entrepreneur with assets in place must finance a platform whose success probability she privately knows. She can issue senior debt, outside equity in the residual, and tokens that confer a share of platform value and turn their buyers into users. [Lemma 1](#) shows

that, under any investor belief, a contract affects her payoff only through two numbers: investors' payoff in the failure state, F , and the number of investor-users, α . Only the amount raised against success-state payoffs, $I - F$, is mispriced, so F measures how well the contract avoids dilution, and α measures adoption.

This representation makes the high type's problem transparent. To minimize dilution she fills the failure state as far as possible, which means safe debt up to the value of assets in place. Beyond that point tokens dominate every other claim (Proposition 2), and outside equity is dominated on both margins (Proposition 1). Whether tokens are issued before safe debt is exhausted depends on Condition A, which holds when each token is a large claim on the existing user base relative to the single user it adds. Airdrops, free distributions of tokens, do not deliver users at no cost: they give away a claim on platform value, and a sale dominates them whenever a sale is feasible (Proposition 3).

What a token sale reveals. With pessimistic off-path beliefs, the high type cannot finance a small project with safe debt in a pooling equilibrium. The low type prefers to reveal itself and sell tokens at a fair price, because a fairly priced token sale still brings users (Corollary 2). The same force governs every separating equilibrium. In the baseline, in which serving users is free and both types retain users equally well, the low type sells strictly more tokens than the high type in every separating equilibrium, whatever the off-path beliefs and whether types differ in default risk, in the value of users, or in both (Theorem 1). Throughout the paper I call a token sale *bad news* when, in a separating equilibrium, the low type sells more tokens, and *good news* when the high type does.

The bad-news result rests on one property: at its own fair price, the low type values users. Section 6.4 shows that this property fails, and the result reverses, when users are costly to serve and good platforms retain them better (Theorem 2). The low type's gain from mimicking a token sale then splits into the net value of users, which is negative for it, and a mispricing subsidy, which is small when tokens are dispersed among users rather than concentrated claims on an incumbent user base. Token sales are bad news when users are cheap to serve, uninformative at intermediate costs because no type sells tokens, and good news when users are costly and tokens dispersed. Corollary 3 gives a simple condition for the good-news region to exist.

Refinement. The separating equilibrium in which the high type issues only safe debt relies on pessimistic beliefs that the Intuitive Criterion rejects: a small, fairly priced token sale benefits only the high type (Proposition 6). The surviving outcome is the least-cost separating equilibrium, in which both types sell tokens and the low type sells more (Proposition 7). For larger projects, pooling on safe debt plus tokens survives D1 (Proposition 8): once the pooled contract exhausts safe debt, every deviation that tempts the high type tempts the low type more. Between these regions there is a semi-separating equilibrium in which the low type randomizes between pooling and a fair token sale (Proposition 9). Together these results characterize the refined equilibrium across project sizes.

Extensions. Tokens might dominate in the baseline only because they are modeled as an equity-like claim plus a free externality. With a deadweight cost of issuing tokens and partial cannibalization of late adopters, the high type sells tokens only up to an interior quantity and finances the rest with risky debt (Proposition 10). Tokens are used at all only if the network value of a marginal user exceeds the deadweight cost of a claim on the existing user base. When types differ in the value of users rather than in default risk, debt is nearly information-insensitive, tokens are the most sensitive claim, and debt dominates at every scale (Proposition 11). Finally, when holding tokens makes users more likely to stay, tokens act on both margins: they create adoption and, by raising every type’s success probability, lower the rate at which all success-state claims are mispriced. With enough retention tokens move ahead of debt, and pooling on token issuance becomes sustainable even for small projects (Propositions 12 and 13).

Related literature. The paper belongs to the literature on security design under asymmetric information initiated by Myers and Majluf (1984), with the optimality of debt established by Innes (1990), Nachman and Noe (1994) and DeMarzo and Duffie (1999); signaling through retained ownership follows Leland and Pyle (1977). The refinement analysis uses the Intuitive Criterion of Cho and Kreps (1987), the divinity criterion of Banks and Sobel (1987), least-cost separation following Riley (1979), and the undefeated equilibrium of Mailath et al. (1993).

The theory of tokens and platform finance has grown quickly. Catalini and Gans (2018) study tokens as a means of financing and of signaling demand. Cong et al. (2021) and Cong et al. (2022) model dynamic adoption and token-based platform finance. Sockin and Xiong (2023) analyze the interaction between token prices and user participation, and Li and Mann (2018) study tokens as a coordination device for platform building. Goldstein et al. (2024) show that utility tokens can commit platforms to competition; Malinova and Park (2023) compare tokens and equity under moral hazard; Gryglewicz et al. (2021) study optimal financing with tokens; Chod and Lyandres (2021) develop a theory of ICOs with diversification, agency and information asymmetry; and Chod et al. (2022) study platform tokenization, governance and moral hazard. Relative to this work, I embed investor-users in the classical security-design problem under asymmetric information, obtain a two-number representation that delivers the pecking order directly, and characterize the refined equilibria. The closest antecedent on information is Chod and Lyandres (2021). The closest on investor-users is the crowdfunding literature, in which buyers are both financiers and customers (Strausz, 2017; Chemla and Tinn, 2020). Empirically, Howell et al. (2020) and Davydiuk et al. (2023) find that founders’ token retention predicts success, which is consistent with the baseline bad-news result.

Outline. Section 2 presents the model. Section 3 studies security design under pooled beliefs. Section 4 characterizes equilibria and what token sales reveal, and Section 5 applies refinements. Section 6 contains extensions, including the conditions under which token sales are good news. Section 7 discusses which results depend on modeling choices, Section 8 collects empirical implications, and Section 9 concludes. Proofs are in the Appendix.

2 Model

Agents and information. A risk-neutral entrepreneur privately knows her type $\theta \in \{G, B\}$, with prior $\Pr(G) = \pi \in (0, 1)$. A unit mass of competitive, risk-neutral investors are also potential platform users. The discount rate is zero.

Technology. The firm owns assets in place worth $K \geq 0$ in every state. Launching the platform requires an outlay $I > 0$. The platform succeeds with probability p_θ , where $p_G = p > p_B = q > 0$; success is the event that early users stay. Let $\bar{p} = \pi p + (1 - \pi)q$.

Platform value. On success the platform is worth

$$W(\alpha) = A(L + \alpha), \quad (1)$$

where $A > 0$ is the value per active user, $L > 0$ is the mass of late adopters, and α is the mass of early token buyers, who become users. On failure the platform is worth zero.

Tokens. The total token supply is $\bar{N} \geq 1$. Selling $\alpha \in [0, 1]$ tokens gives buyers the share $\varphi(\alpha) = \alpha/\bar{N}$ of $W(\alpha)$. Tokens have no claim on K , and the entrepreneur retains the share $1 - \varphi(\alpha)$.

Contracts. A contract is $c = (D, s, \alpha)$, where $D \geq 0$ is the face value of senior debt, $s \in [0, 1]$ is outside equity in the residual after debt, and α is the number of tokens sold. Firm assets are $K + (1 - \varphi)W(\alpha)$ on success and K on failure. Investors' aggregate payoffs on success and on failure are

$$S(c) = \min\{D, K + (1 - \varphi)W\} + s(K + (1 - \varphi)W - D)^+ + \varphi W, \quad (2)$$

$$F(c) = \min\{D, K\} + s(K - D)^+. \quad (3)$$

Pricing and payoffs. If investors believe that the success probability is $\mu \in [q, p]$, the contract must raise exactly I :

$$\mu S(c) + (1 - \mu)F(c) = I. \quad (4)$$

The entrepreneur of type θ receives

$$U_\theta(c) = K + p_\theta W(\alpha) - [p_\theta S(c) + (1 - p_\theta)F(c)], \quad (5)$$

and not investing yields K .

Notation. Token proceeds under belief μ are $\tau_\mu(\alpha) = \mu \alpha A(L + \alpha)/\bar{N}$, extended to $[0, \infty)$ by the same formula; τ_μ is continuous, strictly increasing and unbounded. I write $\tau \equiv \tau_{\bar{p}}$, and

$m(\mu) = (p - \mu)/\mu$ for the rate at which the high type's success-state claims are mispriced under belief μ , with $m \equiv m(\bar{p})$. Define

$$\alpha_K(\mu) = \tau_\mu^{-1}((I - K)^+), \quad \alpha^{\max}(\mu) = \min\{1, \tau_\mu^{-1}(I)\}, \quad \hat{\alpha}(\mu) = \frac{1}{2} \left(\frac{p\bar{N}}{p - \mu} - L \right), \quad (6)$$

with $\hat{\alpha}(p) = +\infty$. Here α_K is the token sale that exactly replaces all risky claims, $\alpha^{\max}$ is the largest token sale consistent with exact raising, and $\hat{\alpha}$ is the high type's preferred token sale beyond safe debt capacity when capacity constraints are ignored. I write α_K , $\alpha^{\max}$ and $\hat{\alpha}$ for their values at $\mu = \bar{p}$.

Assumption 1 (Feasibility). For $\mu \in \{q, \bar{p}\}$: $I - \tau_\mu(1) \leq K + \mu(1 - 1/\bar{N})A(L + 1)$.

Assumption 2 (Exact raising). Contracts raise exactly I ; any excess funds would be dissipated.

3 Security design under pooled beliefs

3.1 Dilution and adoption

Lemma 1 (Two-number representation). *If c is priced at belief μ , then $I \geq F(c)$ and*

$$U_\theta(c) = K - I + p_\theta A(L + \alpha) - \frac{p_\theta - \mu}{\mu} (I - F(c)). \quad (7)$$

Under any belief, a contract matters to the entrepreneur only through investors' failure-state payoff F and the number of investor-users α . Relative to the full-information payoff without investor-users, the high type's payoff has two parts:

$$U_G(c) - (K - I + pAL) = \underbrace{pA\alpha}_{\text{adoption}} - \underbrace{m(\mu)(I - F(c))}_{\text{dilution}}. \quad (8)$$

Dilution is the value that the high type transfers to new investors by selling claims at the pooled price. It is proportional to $I - F$, the amount raised against success-state payoffs, because a claim's failure-state payoff is worth the same under every belief and cannot be mispriced. Adoption is the value of the users that the contract creates. A security helps the high type to the extent that it raises F for a given amount raised, as debt does, or raises α , as tokens do.

Lemma 2 (Attainable failure payoffs). *Fix α and μ with $\tau_\mu(\alpha) \leq I$. Every contract satisfies $F \leq \min\{K, I - \tau_\mu(\alpha)\}$. Under Assumption 1, the bound is attained by a contract with $s = 0$.*

Proposition 1 (The two margins). *Fix a belief μ and an amount to be raised.*

- (i) Debt minimizes dilution. *Among contracts with a given number of tokens, pure debt attains the maximal failure payoff $\min\{K, I - \tau_\mu(\alpha)\}$, and hence minimal dilution.*
- (ii) Only tokens create adoption. *Debt and equity create no users; each token sold creates one.*

- (iii) Equity is dominated on both margins. For any contract with outside equity $s > 0$, replacing the equity with debt while holding α fixed weakly reduces dilution, strictly if $D < K$, and leaves adoption unchanged. Beyond safe debt capacity, replacing the equity with tokens that raise the same amount leaves dilution unchanged and strictly increases adoption.

The pecking order below is the order in which the two margins bind. The high type first eliminates dilution where it can, through safe debt. Once safe debt is exhausted, all remaining claims are mispriced at the same rate, and she maximizes adoption.

3.2 The high type's optimal security

By Lemmas 1 and 2, the high type's problem under belief μ is to set $F = \min\{K, I - \tau_\mu(\alpha)\}$, so that $I - F = \max\{I - K, \tau_\mu(\alpha)\}$, and to solve

$$\min_{\alpha \in [0, \alpha^{\max}(\mu)]} \Gamma_\mu(\alpha) = m(\mu) \max\{I - K, \tau_\mu(\alpha)\} - pA\alpha. \quad (9)$$

The first term is dilution and the second is adoption, as in (8).

Proposition 2 (Optimal security). *For every $\mu \in [q, p)$, the high type's optimal contract under belief μ is unique in α , with*

$$\alpha^*(\mu) = \min \{ \max\{\alpha_K(\mu), \hat{\alpha}(\mu)\}, \alpha^{\max}(\mu) \}, \quad F^*(\mu) = \min\{K, I - \tau_\mu(\alpha^*(\mu))\}, \quad (10)$$

and it is implemented by tokens and debt alone ($s = 0$). Moreover, (a) any contract with $s > 0$ and $D < K$ is strictly dominated; (b) any contract with $s > 0$ and $D \geq K$ is payoff-equivalent to the contract that replaces the equity with additional debt.

Corollary 1 (Pecking order with tokens). *Suppose*

$$\text{Condition A:} \quad (p - \bar{p})L \geq p\bar{N} \quad (\text{equivalently } \hat{\alpha} \leq 0). \quad (11)$$

Then under pooled beliefs the high type's optimal contract is: (i) for $I \leq K$, safe debt only; (ii) for $K < I \leq K + \tau(1)$, safe debt $D = K$ plus tokens raising $I - K$; (iii) for $I > K + \tau(1)$, safe debt, the full token supply on offer ($\alpha = 1$), and risky debt for the remainder. Outside equity is never strictly optimal.

Once safe debt capacity is exhausted, risky debt, junior equity and tokens are all pure success-state claims and are equally mispriced at the margin, and only tokens bring users. Condition A says that each token carries a large claim on the existing user base L , so that, before safe capacity is exhausted, the mispricing of a token exceeds the value of the single user it adds. If Condition A fails ($\hat{\alpha} > 0$), the high type sells tokens even when $I \leq K$, displacing safe debt.

3.3 Airdrops

One might think that a free distribution of tokens delivers users without any mispricing. It does not, because an airdrop transfers a claim on platform value. Suppose the entrepreneur may, in addition to selling α_s tokens, distribute $\alpha_a \geq 0$ tokens for free, and that recipients become users, so that the total number of users is $\alpha = \alpha_s + \alpha_a$.

Proposition 3 (Airdrops). (i) For any type and belief $\mu \in [q, p]$, if the proceeds from selling all α tokens at belief μ do not exceed I , converting the airdrop into a sale strictly raises the entrepreneur's payoff. (ii) If token sales alone already raise I ($F = 0$ and $\alpha_s = \alpha^{\max}(\mu) < 1$), a marginal airdrop raises type θ 's payoff if and only if

$$\bar{N} > L + 2\alpha_s. \quad (12)$$

In particular, under Condition A airdrops are never used.

Airdrops are therefore useful only for platforms whose token supply is large relative to their user base, so that users hold most tokens, and whose funding needs are already met by sales.

4 Equilibrium

I study perfect Bayesian equilibria (PBE). I assume throughout that both types weakly prefer investing under the contracts considered.

4.1 Pessimistic beliefs

In this subsection, investors attribute every off-path contract to the low type.

Proposition 4 (Pooling). Suppose $\tilde{\alpha} = \min\{\max\{\alpha_K, \hat{\alpha}\}, 1\}$ satisfies $\tau(\tilde{\alpha}) \leq I$, which holds under Condition A. Then pooling on $c^* = c^*(\bar{p})$ is a PBE if and only if

$$qA(\alpha^{\max}(q) - \alpha^*) \leq \frac{\bar{p} - q}{\bar{p}} (I - F^*). \quad (B)$$

The left side of (B) is the additional network value that the low type obtains by revealing itself and selling the largest fairly priced token issue. The right side is the mispricing subsidy it enjoys by pooling.

Corollary 2 (Pooling fails for small projects). Under Condition A with $I \leq K$, pooling fails: $\alpha^* = 0$ and $F^* = I$, so the right side of (B) is zero while the left side is $qA\alpha^{\max}(q) > 0$.

Safe debt gives the low type no mispricing subsidy, whereas a fairly priced token sale still gives it network value.

Proposition 5 (Separation with pessimistic beliefs). Under Condition A with $I \leq K$, the following is a PBE: the high type issues safe debt $D = I$; the low type sells $\alpha^{\max}(q)$ tokens at the fair price and covers any remainder with safe debt.

4.2 What a token sale reveals

The next result holds in every separating equilibrium, whatever the off-path beliefs. To state it in its natural generality, let types differ in both success probability and user value: type θ has success probability p_θ and value per user A_θ , with $p_G \geq p_B$, $A_G \geq A_B > 0$, and at least one inequality strict.

Theorem 1 (Token sales are bad news in the baseline). *Under Assumption 2, in every separating PBE the low type sells its largest fairly priced token issue, $\alpha_B = \alpha_B^{\max}$, and the high type sells strictly fewer tokens: $\alpha_G < \alpha_B$.*

The logic is a single-crossing property that runs against tokens. A fairly priced token sale is attractive to the low type because it brings users at no mispricing cost, so the low type's full-information optimum is to sell as many tokens as exact raising permits. Mimicking a contract with at least as many tokens would give the low type at least as many users and, in addition, a strictly positive mispricing subsidy on the tokens themselves. Separation therefore requires the high type to sell fewer tokens. The argument does not depend on which dimension of private information drives the mispricing. It does depend on the low type valuing users at its fair price, and Section 6.4 shows what happens when it does not.

5 Refinement

5.1 Pessimistic separation fails the Intuitive Criterion

Proposition 6 (Pessimistic separation fails). *The separating equilibrium of Proposition 5 fails the Intuitive Criterion.*

The deviation that breaks it is a small token sale on top of safe debt. Priced at the high type's valuation, the deviation gives the high type users at no cost. The low type, which already makes a large fairly priced token sale, gains nothing from a small one even at the most favorable price. The Intuitive Criterion therefore requires investors to attribute the deviation to the high type, and the high type takes it.

5.2 Least-cost separation

Let $\alpha_q^{\max} \equiv \alpha^{\max}(q)$, and define the low type's payoff from mimicking a high-type contract with α tokens and maximal failure payoff, priced at p , net of $K - I + qAL$:

$$\Lambda(\alpha) \equiv qA\alpha + \frac{p-q}{p} \max\{I - K, \tau_p(\alpha)\}. \quad (13)$$

The low type does not mimic if $\Lambda(\alpha) \leq qA\alpha_q^{\max}$. Λ is continuous and strictly increasing. Define the separation condition

$$\frac{p-q}{p} (I-K)^+ \leq qA\alpha_q^{\max}, \quad (\text{S})$$

which holds automatically for $I \leq K$.

Proposition 7 (Least-cost separation). *Suppose Condition A holds and $I \leq \tau_q(1)$. A separating PBE that survives the Intuitive Criterion exists if and only if (S) holds. In it, the low type sells $\alpha_q^{\max}$ tokens at the fair price, and the high type issues safe debt $\min\{I, K\}$, sells*

$$\alpha_G^R = \max\{\alpha \leq \alpha^{\max}(p) : \Lambda(\alpha) \leq qA\alpha_q^{\max}\} \quad (14)$$

tokens at price p , and finances any remainder with fairly priced risky debt; $\alpha_G^R > 0$ whenever (S) holds strictly. This is the unique separating equilibrium that survives the Intuitive Criterion.

In the least-cost separating equilibrium both types sell tokens and the low type sells more, so token sales remain bad news in the sense of Theorem 1. The high type would like to sell more tokens, since at its own fair price tokens bring users without dilution, but it is held back by the low type's incentive to mimic.

5.3 Pooling survives D1

The pooling equilibrium survives refinement whenever the pooled contract exhausts safe debt.

Lemma 3 (No deviation attracts only the high type). *Consider an equilibrium outcome in which both types issue a contract with failure payoff F^* and α^* tokens, priced at belief $\mu \in (q, p)$. For any deviation with failure payoff $F' \leq F^*$ and α' tokens, and any belief μ' , let $\Delta_\theta(\mu')$ denote type θ 's gain from the deviation. Then the set of beliefs under which the high type gains is contained in the set under which the low type gains:*

$$\{\mu' : \Delta_G(\mu') > 0\} \subseteq \{\mu' : \Delta_B(\mu') > 0\}. \quad (15)$$

Proposition 8 (Pooling survives D1). *If the pooled contract satisfies $F^* = K$, which holds for $I > K$ under Condition A, the pooling equilibrium of Proposition 4 survives D1 and therefore the Intuitive Criterion.*

Once the failure state is filled with safe debt, any deviation is at least as information-sensitive as the pooled contract. The low type always gains more from a deviation of this kind, because it benefits from being priced favorably on exactly those claims.

5.4 The intermediate region: semi-separation

When neither (S) nor (B) holds, neither a pure separating nor a pooling equilibrium exists. Consider outcomes in which the high type issues $c^*(\mu)$, the low type issues $c^*(\mu)$ with probability

Table 2: Refined equilibrium by project size

I	Regime	High type's tokens	Low type's tokens	Pr(low type pools)
0.5	Least-cost separation	0.040	0.239	0
1.0	Least-cost separation	0.075	0.458	0
1.2	Least-cost separation	0.089	0.541	0
1.5	Least-cost separation	0.037	0.662	0
1.55	Semi-separation	0.166	0.166 or 0.682	0.667
1.6	Semi-separation	0.191	0.191 or 0.702	0.935
2.0	Pooling	0.314	0.314	1
2.5	Pooling	0.458	0.458	1

Notes: $p = 0.8$, $q = 0.4$, $\pi = 0.5$, $A = 1$, $\bar{N} = 1$, $L = 5$, $K = 1$. Separation for $I \leq 1.544$; semi-separation on $(1.544, 1.612)$, with pooled belief $\mu_h = 0.640$ at $I = 1.55$ and 0.607 at $I = 1.6$, and $F^*(\mu_h) = K$; pooling for $I \in [1.612, 2.830]$. In the separating region the high type finances the remainder with safe debt and, for $I > K$, with fairly priced risky debt.

$\sigma \in (0, 1)$ and otherwise sells $\alpha_q^{\max}$ tokens at the fair price, and investors' belief on the pooled contract is

$$\mu(\sigma) = \frac{\pi p + (1 - \pi)\sigma q}{\pi + (1 - \pi)\sigma}. \quad (16)$$

Define the low type's net gain from pooling at belief μ ,

$$H(\mu) \equiv \frac{\mu - q}{\mu} (I - F^*(\mu)) - qA(\alpha_q^{\max} - \alpha^*(\mu)), \quad (17)$$

and the limit condition

$$\lim_{\mu \uparrow p} H(\mu) > 0. \quad (\text{H})$$

Proposition 9 (Semi-separation). *Suppose (B) fails, (H) holds, and, for all $\mu \in [\bar{p}, p)$,*

$$\tau_\mu(\min\{\max\{\alpha_K(\mu), \hat{\alpha}(\mu)\}, 1\}) \leq I.$$

Then there exists $\mu_h \in (\bar{p}, p)$ with $H(\mu_h) = 0$, and a semi-separating PBE in which the low type pools with probability

$$\sigma_h = \frac{\pi(p - \mu_h)}{(1 - \pi)(\mu_h - q)} \in (0, 1). \quad (18)$$

If $F^*(\mu_h) = K$, the equilibrium survives D1.

5.5 The refined equilibrium by project size

Table 2 reports the refined equilibrium in a numerical example with $p = 0.8$, $q = 0.4$, $\pi = 0.5$ (so $\bar{p} = 0.6$ and $m = 1/3$), $A = 1$, $\bar{N} = 1$, $L = 5$ and $K = 1$, for which Condition A holds. Condition (S) holds for $I \leq 1.544$, condition (B) holds for $I \geq 1.612$, and the low type's participation constraint under pooling holds for $I \leq 2.830$.

Three features of the table are worth noting. First, token sales are most informative for small

projects, where safe debt would suffice and only network motives remain. Second, within the separating region the high type's token sale is not monotone in project size: once $I > K$, the low type's gain from mimicking includes the mispricing of risky debt, and the high type must sell fewer tokens to deter it. Third, semi-separating equilibria with $F^*(\mu) < K$ also exist for smaller projects, but in the example they fail the Intuitive Criterion; in the semi-separating region of the table $F^*(\mu_h) = K$, so Proposition 9 applies.

6 Extensions

6.1 Real costs of tokens

The baseline treats the user externality of tokens as free. Suppose instead that issuing tokens incurs a deadweight cost proportional to proceeds, $\lambda \tau_\mu(\alpha)$ with $\lambda \geq 0$, reflecting regulatory compliance, exchange listing, or the cost of attracting speculators. Suppose also that a fraction $\kappa \in [0, 1)$ of token buyers would have joined as late adopters anyway, so that platform value is $W(\alpha) = A(L + (1 - \kappa)\alpha)$ and proceeds are $\tau_\mu(\alpha) = \mu \alpha A(L + (1 - \kappa)\alpha) / \bar{N}$. Define

$$\alpha_\lambda = \frac{1}{2(1 - \kappa)} \left(\frac{p(1 - \kappa)\bar{N}}{\lambda \bar{p}} - L \right), \quad \hat{\alpha}_\lambda = \frac{1}{2(1 - \kappa)} \left(\frac{p(1 - \kappa)\bar{N}}{(m + \lambda)\bar{p}} - L \right). \quad (19)$$

Proposition 10 (Issuance costs). *Under pooled beliefs, the high type's optimal token sale is*

$$\alpha_\lambda^* = \min \{ \alpha^{\max}, \max \{ \min \{ \alpha_\lambda^+, \alpha_K \}, \hat{\alpha}_\lambda \} \}, \quad (20)$$

with failure payoff $\min \{ K, I - \tau(\alpha_\lambda^*) \}$. In particular, for $I > K$ tokens are issued if and only if

$$p(1 - \kappa)\bar{N} > \lambda \bar{p}L. \quad (\text{T})$$

If $0 < \alpha_\lambda < \alpha_K$, the high type issues safe debt, then tokens up to α_λ , then risky debt.

In the baseline, risky debt is used only after the token supply on offer is exhausted (Corollary 1). With issuance costs, the high type stops selling tokens at an interior quantity and finances the rest with risky debt. Beyond safe debt capacity, tokens and risky debt are equally mispriced, so their ranking depends only on whether a token's network value exceeds its deadweight cost, which is proportional to the token's claim on existing users. In the example of Table 2, with $\kappa = 0$, $\lambda = 0.25$ gives $\alpha_\lambda = 0.167$: for $I = 2$ the high type sells 0.167 tokens rather than 0.314 and finances the rest with risky debt. For $\lambda \geq 0.267$, condition (T) fails and no tokens are issued.

6.2 Private information about user value

Suppose now that types share the success probability p but differ in user value, $A_G > A_B$, with $\bar{A} = \pi A_G + (1 - \pi)A_B$. Debt whose face value does not exceed $K + (1 - \varphi)A_B(L + \alpha)$ pays the

same in each state for both types and is therefore fairly priced under any belief. Tokens, whose payoff scales with A , are the most information-sensitive claim.

Proposition 11 (Debt dominance under user-value asymmetry). *Suppose types differ only in A and $I \leq K + pA_B L$. Under pooled beliefs, the high type's optimal contract consists of debt and*

$$\alpha_A^* = \min \left\{ \alpha^{\max}, \max \left\{ 0, \frac{1}{2} \left(\frac{A_G \bar{N}}{A_G - \bar{A}} - L \right) \right\} \right\} \quad (21)$$

tokens, independently of I . If $(A_G - \bar{A})L \geq A_G \bar{N}$, the high type uses debt only, at every scale up to debt capacity. Outside equity is strictly dominated. Pooling on debt alone is not an equilibrium: the low type prefers to reveal itself through a fair token sale.

The position of tokens in the pecking order is thus driven by asymmetric information about default risk. When the asymmetry concerns user demand, debt is nearly information-free and dominates at every scale, and the bad-news property of Theorem 1 continues to apply.

6.3 Retention: tokens that keep users

So far token buyers *join* the platform, but holding a token does not affect whether users *stay*. Tokens may also serve retention: an investor who holds a stake in the platform has a reason to remain an active user, which makes the platform, and the tokens, more valuable. I capture this with the simplest functional form. Holding tokens raises the success probability of both types by the same amount,

$$p_\theta(\alpha) = p_\theta + r\alpha, \quad r \geq 0, \quad p + r \leq 1. \quad (22)$$

Under belief μ about the baseline success probability, investors expect success with probability $\mu + r\alpha$, and token proceeds are $\tau_\mu^r(\alpha) = (\mu + r\alpha)\alpha A(L + \alpha)/\bar{N}$.

Lemma 4 (Two margins with retention). *If c is priced at belief μ , then*

$$U_\theta(c) = K - I + (p_\theta + r\alpha)A(L + \alpha) - \frac{p_\theta - \mu}{\mu + r\alpha}(I - F(c)). \quad (23)$$

The type difference $p_\theta - \mu$ in the numerator is unaffected by retention, while the denominator rises. Retention therefore gives tokens a role on *both* margins of Section 3. On the adoption margin, each token now brings a user and raises the probability that the platform's users stay, adding $r\alpha A(L + \alpha)$ in expected value. On the dilution margin, the high type's mispricing rate

$$m_r(\alpha) = \frac{p - \mu}{\mu + r\alpha} \quad (24)$$

is strictly decreasing in α . By making success more likely for every type, tokens make all success-state claims, risky debt included, less sensitive to the entrepreneur's private information. With retention, tokens partly substitute for debt on the margin on which debt is strongest.

Table 3: Retention, token sales, and pooling

Retention r	High type's pooled token sale α_r^* (pooling holds?)			
	$I = 0.5$	$I = 1.0$	$I = 1.5$	$I = 2.0$
0	0 (no)	0 (no)	0.161 (no)	0.314 (yes)
0.05	0.159 (yes)	0.167 (no)	0.167 (no)	0.306 (no)
0.10	0.157 (yes)	0.300 (yes)	0.430 (yes)	0.550 (yes)

Notes: Parameters as in Table 2. "Pooling holds" refers to condition (B_r) with pessimistic beliefs. For $r = 0.1$ the token sale equals $\alpha_r^{\max}$, so projects are fully token-financed.

Define the retention-adjusted condition and stationary point

$$\text{Condition } A_r : (p - \bar{p} - r\bar{N})L \geq p\bar{N}, \quad \hat{\alpha}_r = \frac{1}{2} \left(\frac{p\bar{N}}{p - \bar{p} - r\bar{N}} - L \right) \text{ if } p - \bar{p} > r\bar{N}, \quad (25)$$

and let α_K^r and $\alpha_r^{\max}$ be defined as α_K and $\alpha^{\max}$, with τ^r in place of τ .

Proposition 12 (Optimal security with retention). *Under pooled beliefs, the high type's optimal contract uses debt and tokens only, with*

$$\alpha_r^* = \begin{cases} \min \{ \max \{ \alpha_K^r, \hat{\alpha}_r \}, \alpha_r^{\max} \} & \text{if } p - \bar{p} > r\bar{N}, \\ \alpha_r^{\max} & \text{if } p - \bar{p} \leq r\bar{N}. \end{cases} \quad (26)$$

In particular: (i) retention weakens Condition A, which fails for $r > (p - \bar{p}) / \bar{N} - p / L$; (ii) when Condition A_r fails, the high type issues tokens even for projects that safe debt could fund; (iii) when $r\bar{N} \geq p - \bar{p}$, the high type finances as much of the project as possible with tokens, and debt is used only for any remainder.

Retention also changes the equilibrium. Token sales remain bad news in any separating equilibrium: because retention is common to both types, the argument of Theorem 1 applies unchanged. A fairly priced token sale is still attractive to the low type, and mimicking a larger token sale still yields it a mispricing subsidy. But because the high type now issues tokens even for small projects, the low type enjoys a subsidy from pooling where it previously had none, and pooling becomes sustainable where it previously failed.

Proposition 13 (Pooling with retention). *Suppose the high type's unconstrained optimum is feasible under pooled pricing. Pooling on the contract of Proposition 12 is a PBE with pessimistic beliefs if and only if*

$$(q + r\alpha_{r,q}^{\max})A(L + \alpha_{r,q}^{\max}) - (q + r\alpha_r^*)A(L + \alpha_r^*) \leq \frac{\bar{p} - q}{\bar{p} + r\alpha_r^*} (I - F_r^*), \quad (B_r)$$

where $\alpha_{r,q}^{\max}$ is the largest token sale consistent with exact raising at belief q and $F_r^* = \min\{K, I - \tau_p^r(\alpha_r^*)\}$.

Table 3 reports the example of Section 5 for three degrees of retention. Without retention, pooling requires $I \geq 1.612$. With $r = 0.05$, the high type sells tokens even for small projects;

pooling holds for $I \leq 0.9$, fails for intermediate projects, and holds again for $I \geq 2.1$. With $r = 0.1$, $\hat{\alpha}_r = 1.5$ exceeds the token supply on offer, so the high type finances projects entirely with tokens, and pooling holds over the whole range considered.

The extension clarifies the baseline. When tokens only bring users, they are the best of several equally mispriced claims and are issued after safe debt. When they also keep users, they reduce dilution as well and can be issued ahead of debt. The equilibrium then shifts from separation, in which token sales reveal the low type, toward pooling, in which both types issue tokens and the market learns little from the sale.

6.4 When are token sales good news?

Theorem 1 rests on one property: at its own fair price, the low type values users, and so wants to sell as many tokens as it can. Two features absent from the baseline overturn this property, and with it the bad-news result. First, good platforms keep their users better than bad ones. Second, users are costly to serve: onboarding, support, infrastructure and community management absorb the founder's resources whether or not the platform succeeds. Together these features make users valuable to the high type and unprofitable for the low type.

Setup. Holding tokens raises the success probability by a type-specific amount,

$$p_\theta(\alpha) = p_\theta + r_\theta \alpha, \quad r_G \geq r_B \geq 0, \quad p + r_G \leq 1, \quad (27)$$

and each user costs the entrepreneur $\omega \geq 0$, a private cost not financed through the contract. Type θ 's value from α users at a fair price, net of $K - I$, is

$$V_\theta(\alpha) = (p_\theta + r_\theta \alpha)A(L + \alpha) - \omega \alpha, \quad (28)$$

which is convex in α , so fair-price optima are at corners. Let $\alpha_\theta^{\max}$ be the largest token sale consistent with exact raising at type θ 's fair price; since the high type's tokens sell at a higher price, $\alpha_G^{\max} \leq \alpha_B^{\max}$. I focus on projects that safe debt can fund, $I \leq K$, where the baseline bad-news result is starkest. Define the thresholds

$$\omega_B = A[q + r_B(L + \alpha_B^{\max})], \quad \omega_\psi = A\left[q + r_B L + \frac{(p - q)L}{N}\right], \quad (29)$$

and assume $(p - q)L \geq r_B \alpha_B^{\max} N$, so that $\omega_\psi \geq \omega_B$.

Lemma 5 (The low type's gain from mimicking). *Let $I \leq K$. If the high type sells α tokens at its fair price and finances the remainder with safe debt, the low type's gain from mimicking it, relative to issuing safe debt alone, is $A\alpha\psi(\alpha)$, where*

$$\psi(\alpha) = \underbrace{q + r_B(L + \alpha) - \frac{\omega}{A}}_{\text{net value of users to the low type}} + \underbrace{\left[(p - q) + (r_G - r_B)\alpha\right] \frac{L + \alpha}{N}}_{\text{mispricing subsidy per token}}. \quad (30)$$

The function ψ is strictly increasing in α and strictly decreasing in ω .

Mimicking a token sale gives the low type users, whose net value to it is negative when ω is high and its retention is weak, and a mispricing subsidy, which is large when each token is a claim on many existing users ($L/\bar{N}$ large) and when the high type's superior retention is priced into the token. When $\psi(0) < 0$, let $\bar{\alpha}(\omega) = \max\{\alpha \leq \alpha_G^{\max} : \psi(\alpha) \leq 0\}$.

Theorem 2 (When are token sales good news?). *Let $I \leq K$.*

- (i) *Bad news. If $\omega < \omega_B$, then in every separating PBE the low type sells $\alpha_B^{\max}$ tokens and the high type sells strictly fewer.*
- (ii) *The low type sells no tokens. If $\omega > \omega_B$, then in every separating PBE the low type sells no tokens. Two cases arise.*
 - (a) *Good news. If $\omega > \omega_\psi$, $V_G(\bar{\alpha}(\omega)) > V_G(0)$, and the high type does not prefer any deviation priced at the low type's valuation, there is a separating PBE in which the high type sells $\bar{\alpha}(\omega) > 0$ tokens. It is the unique separating PBE that survives the Intuitive Criterion, and pooling on safe debt fails the Intuitive Criterion.*
 - (b) *No token sales. If $\omega_B < \omega \leq \omega_\psi$, no type sells tokens in any separating PBE, and pooling on safe debt survives the Intuitive Criterion.*

Theorem 2 replaces the unconditional bad-news result of the baseline with a characterization; Theorem 1 is the case $\omega = 0$, $r_G = r_B = 0$. Token sales are bad news when users are cheap to serve, because the low type then wants users too and sells as many tokens as it can. They are good news when users are expensive enough that the low type does not want them, provided the subsidy from mimicking is small enough that it does not want to pose as the high type either. Between these regions the low type would mimic any token sale, so the high type does not sell tokens at all.

Token dispersion and retention. Whether the good-news region exists depends on how the mispricing subsidy compares with the high type's advantage in retaining users.

Corollary 3 (Existence of good-news token sales). *Apart from the deviation condition, a non-empty interval of costs ω supports the good-news equilibrium of Theorem 2(ii)(a) if*

$$(p - q) \frac{L - \bar{N}}{\bar{N}} < (r_G - r_B) L, \quad (\text{GN})$$

and only if $(p - q)(L - \bar{N})/\bar{N} < (r_G - r_B)L + r_G \alpha_G^{\max}$. In particular:

- (a) *if the token supply is dispersed relative to the user base, $\bar{N} > L$, good-news token sales exist even without retention differences;*
- (b) *if $\bar{N} < L$, they require a retention advantage of at least $(p - q)(L - \bar{N})/(\bar{N}L)$;*

Table 4: Token sales by cost per user

Cost per user ω	High type's tokens	Low type's tokens	Regime
0.20	0.363	1.000	Bad news
0.40	0.187	1.000	Bad news
0.60	0	0	No token sales
0.90	0	0	No token sales
1.05	0.223	0	Good news
1.15	0.644	0	Good news
1.25	0.787	0	Good news
1.35	0.787	0	Good news
1.40	0	0	No token sales

Notes: $p = 0.8$, $q = 0.4$, $A = 1$, $L = 5$, $\bar{N} = 4$, $I = K = 1$, $r_G = 0.10$, $r_B = 0.02$. Thresholds: $\omega_B = 0.52$, $\omega_\psi = 1.00$; the good-news region ends at $\omega = 1.379$, above which $V_G(\bar{\alpha}(\omega)) < V_G(0)$ and the high type prefers safe debt. In the bad-news region the high type's sale is the least-cost separating quantity; in the good-news region it is $\bar{\alpha}(\omega)$, capped at $\alpha_G^{\max}$.

(c) in the baseline, with $r_G = r_B = 0$ and Condition A (which implies $\bar{N} < L$), they do not exist.

The left side of (GN) is the part of the mispricing subsidy that arises because a token is a claim on the existing user base; it is positive only when tokens are concentrated, $\bar{N} < L$. The right side is the high type's advantage in retaining users. Token sales are good news when tokens are dispersed among users rather than concentrated claims on an incumbent user base, and when good platforms keep their users better. Both features describe utility tokens held by active users more closely than speculative tokens held by investors.

Numerical illustration. Let $p = 0.8$, $q = 0.4$, $A = 1$, $L = 5$, $\bar{N} = 4$, $I = K = 1$, $r_G = 0.10$ and $r_B = 0.02$. Then $\alpha_G^{\max} = 0.787$, $\alpha_B^{\max} = 1$, $\omega_B = 0.52$ and $\omega_\psi = 1.00$, and condition (GN) holds ($0.1 < 0.4$). Table 4 reports the refined separating outcome as the cost per user varies. The good-news region extends up to $\omega = 1.379$, where the high type's value from its largest good-news token sale falls to that of safe debt. The deviation condition of Theorem 2(ii)(a) holds throughout: the high type's best pessimistically priced deviation is safe debt.

The required retention advantage falls sharply with token dispersion. With $r_B = 0.02$ and the other parameters as above, condition (GN) requires $r_G - r_B > 0.32$ when $\bar{N} = 1$, which is infeasible since $p + r_G \leq 1$, but only 0.12 when $\bar{N} = 2$, 0.02 when $\bar{N} = 4$, and nothing at all once $\bar{N} \geq L = 5$.

Over-raising. A second route to good-news token sales relaxes exact raising: a high type could sell more tokens than it needs, as a form of money burning. This requires a discipline on excess funds, such as type-dependent diversion, and I leave it to future work.

7 Discussion: what drives the results

This section separates results that follow from the economics of the problem from results that depend on specific modeling choices.

Results that do not depend on functional form. Lemma 1, the decomposition of every contract into dilution and adoption, does not depend on functional forms. Its implication, that beyond safe debt capacity all outside claims are equally mispriced at the margin and tokens weakly dominate whenever investor-users add value, holds for any increasing token-share function. The dominance of debt over equity is the standard result in two-state models. Theorem 1 holds under exact raising for either source of private information, but only when the low type values users at its fair price. Theorem 2 shows that the result reverses when users are costly to serve and tokens are dispersed. The sign of the information in a token sale is therefore an outcome of the model, not an assumption.

Results that reflect how tokens are modeled. That debt plus tokens dominates equity is close to mechanical in the baseline, where tokens are an equity-like claim plus a free user externality. Proposition 10 shows what survives when the externality is costly: tokens are issued if and only if condition (T) holds, and then only up to an interior quantity. Airdrops do not undermine the baseline, since sales dominate them unless sales already cover the investment (Proposition 3).

Results that depend on Condition A. The prediction that small projects are financed with safe debt alone requires Condition A, which implies $\bar{N} < L$: each token is a claim on value generated by many users. If users hold the tokens, $\bar{N} \geq L + \alpha$ and Condition A fails, because $p - \bar{p} < p$. The model then predicts token sales even for small projects, and Proposition 3 identifies this as the region in which airdrops become useful.

8 Empirical implications

- E1.** *The sign of the information in a token sale.* Where tokens are concentrated claims on an existing user base and users are cheap to serve, larger token sales relative to financing needs predict lower success, and founders' token retention predicts success, consistent with [Howell et al. \(2020\)](#) and [Davydiuk et al. \(2023\)](#). Where tokens are dispersed among active users and users are costly to serve, token sales predict success. The announcement effect of a token sale should therefore vary with token dispersion and with the cost of serving users.
- E2.** *Assets in place.* Ventures with more pledgeable assets in place rely more on debt and sell tokens only beyond that capacity.
- E3.** *Project size.* When users are cheap to serve, the market reaction to a token sale is most

negative for projects that are small relative to assets in place, where the equilibrium is separating, and weakest for large projects, where the equilibrium is pooling.

- E4. *Issuance costs.* Where regulatory costs of token issuance rise, token sales shrink and are replaced by risky debt rather than equity.
- E5. *Retention.* Platforms whose tokens give ongoing benefits to holders who remain active, such as staking, fee discounts or governance rights, sell more tokens relative to debt, and their token sales carry less information.
- E6. *Source of uncertainty.* Ventures whose uncertainty concerns user demand rather than technical viability use more debt and fewer tokens.
- E7. *Token supply.* Airdrops are concentrated among platforms with large token supplies relative to their user base and with funding needs already met by sales.

9 Conclusion

For an entrepreneur with private information, securities differ on two margins. Debt limits dilution, because it is the claim least sensitive to her information. Tokens create adoption, because their buyers become users and raise the value of the platform and of the tokens themselves. Outside equity is weak on both margins and is dominated. The pecking order follows the order in which the margins bind: safe debt first, because it is not mispriced; then tokens, because once safe debt is exhausted all outside claims are mispriced at the same rate and only tokens bring users.

Equilibrium adds a second layer. When users are cheap to serve, a fairly priced token sale is valuable to the low type as well, so in every separating equilibrium the low type sells more tokens and a token sale is bad news. Refinement selects least-cost separation for small projects, in which both types sell tokens and the low type sells more, pooling for large projects, and semi-separation in between. When users are costly to serve and good platforms retain them better, the low type no longer wants users, and token sales become good news, provided tokens are dispersed enough that posing as the high type yields only a small mispricing subsidy. Issuance costs limit token sales to an interior quantity; private information about demand rather than default makes debt dominant at every scale; and a retention role lets tokens reduce dilution as well, moving them ahead of debt and making token sales less informative.

A Proofs

Proof of Lemma 1. Debt and equity payoffs are nondecreasing in firm assets, and firm assets on success are at least K . Token payoffs are $\varphi W \geq 0$ on success and 0 on failure. Hence $S \geq F$.

Equation (4) gives $S - F = (I - F)/\mu \geq 0$, so $I \geq F$. Moreover,

$$p_\theta S + (1 - p_\theta)F = I + (p_\theta - \mu)(S - F) = I + \frac{p_\theta - \mu}{\mu}(I - F).$$

Substituting into U_θ yields the claim. $\square$

Proof of Lemma 2. First, if $D \leq K$, then $F = D + s(K - D) \leq K$; if $D > K$, then $F = K$. Second, the debt-plus-equity claim pays at least as much on success as on failure, and its value equals $I - \tau_\mu(\alpha)$, which is therefore at least F . For attainment, if $I - \tau_\mu(\alpha) \leq K$, set $D = I - \tau_\mu(\alpha)$ and $s = 0$; this debt is riskless, with $F = D$. If $I - \tau_\mu(\alpha) > K$, set $s = 0$. The value of debt, $\mu \min\{D, K + (1 - \varphi)W\} + (1 - \mu)K$, is continuous in D , equals K at $D = K$, and reaches $K + \mu(1 - \varphi)W$ for large D . By the intermediate value theorem and Assumption 1, some $D \geq K$ raises $I - \tau_\mu(\alpha)$, and then $F = K$. $\square$

Proof of Proposition 1. Part (i) is Lemma 2. Part (ii) is immediate from the definitions. For part (iii), the first claim follows from Lemma 2 and part (a) of Proposition 2, whose proof does not use this result. For the second, when $F = K$ all outside claims other than safe debt pay only in the success state, so by Lemma 1 replacing equity with tokens that raise the same amount leaves $I - F$ unchanged and raises α . $\square$

Proof of Proposition 2. Fix μ . On $[0, \min\{\alpha_K(\mu), \alpha^{\max}(\mu)\}]$, $\tau_\mu \leq I - K$ and $\Gamma_\mu = m(\mu)(I - K) - pA\alpha$, which is strictly decreasing. On $[\alpha_K(\mu), \alpha^{\max}(\mu)]$,

$$\Gamma_\mu = g_\mu(\alpha) \equiv m(\mu)\tau_\mu(\alpha) - pA\alpha = A\alpha[(p - \mu)(L + \alpha)/\bar{N} - p],$$

with $g''_\mu = 2(p - \mu)A/\bar{N} > 0$ and stationary point $\hat{\alpha}(\mu)$. Its unique minimizer on that interval is the projection of $\hat{\alpha}(\mu)$. Since Γ_μ is continuous at $\alpha_K(\mu)$, the global minimizer is $\min\{\max\{\alpha_K(\mu), \hat{\alpha}(\mu)\}, \alpha^{\max}(\mu)\}$; if $\alpha_K(\mu) > \alpha^{\max}(\mu)$, Γ_μ is strictly decreasing on $[0, \alpha^{\max}(\mu)]$ and the formula returns $\alpha^{\max}(\mu)$. Lemma 2 implements $F^*(\mu)$ with $s = 0$. For (a), with $D < K$ and $s > 0$, the debt-plus-equity claim is worth $D + s(K - D + \mu(1 - \varphi)W) = I - \tau_\mu(\alpha)$, which strictly exceeds $D + s(K - D) = F$ because $\varphi < 1$; also $F < K$ because $s < 1$. Thus $F < \min\{K, I - \tau_\mu(\alpha)\}$, and by Lemma 1 the contract is strictly worse than the debt contract with the same α . For (b), $D \geq K$ implies $F = K$, which attains the bound. $\square$

Proof of Corollary 1. Under Condition A, $\hat{\alpha} \leq 0 \leq \alpha_K$, so $\alpha^* = \min\{\alpha_K, \alpha^{\max}\}$. If $I \leq K$, $\alpha_K = 0$. If $K < I \leq K + \tau(1)$, then $\alpha_K \leq 1$ and $\tau(\alpha_K) = I - K < I$, so $\alpha^* = \alpha_K$. If $I > K + \tau(1)$, then $\alpha_K > 1$ and $\alpha^* = 1$. $\square$

Proof of Proposition 3. With α_s sold and α_a airdropped, investors' payoffs are as in Lemma 1 with token proceeds $\mu\alpha_s A(L + \alpha)/\bar{N}$, and recipients receive $p_\theta\alpha_a A(L + \alpha)/\bar{N}$ in expectation.

Hence

$$U_\theta = K - I + p_\theta A(L + \alpha) - \frac{p_\theta - \mu}{\mu}(I - F) - p_\theta \frac{\alpha_a A(L + \alpha)}{\bar{N}}.$$

(i) Selling the airdropped tokens raises additional proceeds $x = \mu \alpha_a A(L + \alpha) / \bar{N}$. With F chosen optimally, $I - F = \max\{I - K, \text{proceeds}\}$ rises by some $\Delta \in [0, x]$. The payoff change is $-\frac{p_\theta - \mu}{\mu}\Delta + \frac{p_\theta}{\mu}x$. If $p_\theta \geq \mu$, this is at least $-\frac{p_\theta - \mu}{\mu}x + \frac{p_\theta}{\mu}x = x > 0$; if $p_\theta < \mu$, both terms are non-negative and the second is positive. (ii) With $F = 0$ and exact raising, $\alpha_s(L + \alpha) = I\bar{N}/(\mu A)$ is constant, so $d\alpha_s(L + \alpha) + \alpha_s d\alpha = 0$ with $d\alpha = d\alpha_s + d\alpha_a$; at $\alpha_a = 0$ this gives $d\alpha/d\alpha_a = (L + \alpha_s)/(L + 2\alpha_s)$. The terms in $I - F = I$ are unchanged, so

$$\left. \frac{dU_\theta}{d\alpha_a} \right|_{\alpha_a=0} = p_\theta A \frac{L + \alpha_s}{L + 2\alpha_s} - p_\theta A \frac{L + \alpha_s}{\bar{N}},$$

which is positive if and only if $\bar{N} > L + 2\alpha_s$. Condition A implies $\bar{N} < L$. $\square$

Proof of Proposition 4. *High type.* A deviation c' is priced at q . By Lemmas 1 and 2, $U_G(c') \leq K - I + pAL - \Gamma_q(\alpha')$, with $\Gamma_q(\alpha) = \frac{p-q}{q} \max\{I - K, \tau_q(\alpha)\} - pA\alpha$. For every α , $\frac{p-q}{q}\tau_q(\alpha) = (p-q)A\alpha(L + \alpha)/\bar{N} \geq m\tau(\alpha)$ and $\frac{p-q}{q} \geq m$. Hence $\Gamma_q \geq \tilde{\Gamma}$, where $\tilde{\Gamma}$ is $\Gamma_{\bar{p}}$ without the constraint $\tau \leq I$. By the argument of Proposition 2, $\tilde{\Gamma}$ is minimized on $[0, 1]$ at $\tilde{\alpha}$, which is feasible by hypothesis, so $\tilde{\alpha} = \alpha^*$ and $U_G(c') \leq U_G(c^*)$. *Low type.* By Lemma 1, $U_B(c^*) = K - I + qA(L + \alpha^*) + \frac{\bar{p}-q}{\bar{p}}(I - F^*)$. A deviation priced at q is fairly priced for the low type and yields $K - I + qA(L + \alpha')$, which is maximized at $\alpha' = \alpha^{\max}(q)$, feasible by Lemma 2 at $\mu = q$. The low type does not deviate if and only if (B) holds. Pessimistic beliefs minimize deviation payoffs, so (B) is also necessary. $\square$

Proof of Corollary 2. Immediate from Corollary 1(i). $\square$

Proof of Proposition 5. *Low type:* it obtains $K - I + qA(L + \alpha^{\max}(q))$; any contract priced at q gives at most this, and mimicking the high type's riskless debt gives $K - I + qAL$. *High type:* any deviation priced at q costs $\Gamma_q(\alpha) = A\alpha[(p-q)(L + \alpha)/\bar{N} - p] \geq 0$ when $I \leq K$, since $(p-q)L > (p-\bar{p})L \geq p\bar{N}$. Safe debt, yielding $K - I + pAL$, is optimal. $\square$

Proof of Theorem 1. In a separating PBE each type's contract is priced at its true type. Generalizing Lemma 1, a fairly priced contract yields type θ the payoff $K - I + p_\theta A_\theta(L + \alpha)$. The low type can always obtain at least the fair price, because investors' beliefs on any contract place probability at most one on the low type; hence its equilibrium payoff is at least $K - I + p_B A_B(L + \alpha_B^{\max})$, and since its own contract is fairly priced, $\alpha_B = \alpha_B^{\max}$. If the low type mimics the high type's contract c_G , priced at the high type's valuation, it receives

$$K - I + p_B A_B(L + \alpha_G) + \left(E_G[\text{payoff}(c_G)] - E_B[\text{payoff}(c_G)] \right),$$

where the bracket is non-negative because every claim pays weakly more under a higher success probability and a higher user value. Incentive compatibility requires $p_B A_B (\alpha_G - \alpha_B) + [\cdot] \leq 0$. If $\alpha_G \geq \alpha_B > 0$, the bracket is at least the token term $(\alpha_G / \bar{N})(p_G A_G - p_B A_B)(L + \alpha_G) > 0$, a contradiction. Hence $\alpha_G < \alpha_B$. $\square$

Proof of Proposition 6. Consider the deviation to safe debt $D = I - \tau_p(\epsilon)$ and $\epsilon > 0$ tokens. If priced at p , it gives the high type $K - I + pA(L + \epsilon)$, strictly above its equilibrium payoff $K - I + pAL$. By Lemma 1, it gives the low type at most $K - I + qA(L + \epsilon) + \frac{p-q}{p}\tau_p(\epsilon)$ at any belief, which is below its equilibrium payoff $K - I + qA(L + \alpha^{\max}(q))$ for ϵ small. The Intuitive Criterion requires the deviation to be attributed to the high type, which then deviates. $\square$

Proof of Proposition 7. Equilibrium. Off-path beliefs are q . The low type's on-path payoff is its full-information optimum; mimicking the high type gives $K - I + qAL + \Lambda(\alpha_G^R) \leq K - I + qA(L + \alpha_q^{\max})$ by construction. The high type's on-path payoff is $K - I + pA(L + \alpha_G^R)$. A deviation priced at q yields at most $K - I + pAL - \Gamma_q(\alpha)$. For $\alpha \leq \tau_q^{-1}((I - K)^+)$, $-\Gamma_q(\alpha) \leq pA\alpha - \frac{p-q}{q}\tau_q(\alpha) = -A\alpha[(p - q)(L + \alpha)/\bar{N} - p] \leq 0$ under Condition A; for larger α , $-\Gamma_q = -g_q \leq 0$ likewise. Hence deviations give at most $K - I + pAL$, weakly below the on-path payoff. If (S) holds strictly, $\Lambda(0) < qA\alpha_q^{\max}$ and continuity gives $\alpha_G^R > 0$; for $I \leq K$, $\Lambda(0) = 0 < qA\alpha_q^{\max}$.

Intuitive Criterion. By Lemma 1, a deviation (α', F') priced at p gives the high type $K - I + pA(L + \alpha')$, so it gains only if $\alpha' > \alpha_G^R$. For such α' , the low type's payoff at belief p is

$$K - I + qAL + qA\alpha' + \frac{p-q}{p}(I - F') \geq K - I + qAL + \Lambda(\alpha') > K - I + qA(L + \alpha_q^{\max}),$$

using $I - F' \geq \max\{I - K, \tau_p(\alpha')\}$ and the definition of α_G^R as the largest feasible α with $\Lambda \leq qA\alpha_q^{\max}$ (if $\alpha_G^R = \alpha^{\max}(p)$, no larger α' is feasible at p). Thus every deviation that benefits the high type also benefits the low type, and the equilibrium survives.

Necessity and uniqueness. If (S) fails, $\Lambda(0) > qA\alpha_q^{\max}$: the low type would mimic any high-type contract priced at p whose failure payoff is at most K , which every contract satisfies, so no separating equilibrium exists. In any separating equilibrium, the high type's contract has some α_G with $\Lambda(\alpha_G) \leq qA\alpha_q^{\max}$, by incentive compatibility and because the high type sets F maximal or is dominated. If $\alpha_G < \alpha_G^R$, a deviation to $\alpha' \in (\alpha_G, \alpha_G^R)$ with maximal F' strictly benefits the high type at belief p , while the low type's highest deviation payoff, attained at belief p , is strictly below its equilibrium payoff because $\Lambda(\alpha') < qA\alpha_q^{\max}$. The Intuitive Criterion then eliminates the equilibrium. $\square$

Proof of Lemma 3. By Lemma 1, the equilibrium payoff is $U_\theta^* = K - I + p_\theta[A(L + \alpha^*) - (I - F^*)/\mu] + (I - F^*)$, and the deviation payoff at belief μ' is $K - I + p_\theta[A(L + \alpha') - (I - F')/\mu'] + (I - F')$. Hence

$$\Delta_\theta(\mu') = p_\theta X(\mu') + Y, \quad X(\mu') = A(\alpha' - \alpha^*) - \frac{I - F'}{\mu'} + \frac{I - F^*}{\mu}, \quad Y = F^* - F' \geq 0.$$

$\Delta_G(\mu') > 0$ if and only if $X(\mu') > -Y/p$. Since $Y \geq 0$ and $q < p$, $-Y/q \leq -Y/p$, so $X(\mu') > -Y/p$ implies $X(\mu') > -Y/q$, that is, $\Delta_B(\mu') > 0$. $\square$

Proof of Proposition 8. Under Condition A with $I > K$, $\alpha^* = \alpha_K$ (or 1) and $F^* = K$. Every feasible contract has $F' \leq K = F^*$ by Lemma 2. By Lemma 3, for every deviation the set of beliefs for which the high type gains is contained in the corresponding set for the low type. D1 therefore never requires investors to place zero weight on the low type, and the pessimistic belief is admissible. D1 implies the Intuitive Criterion. $\square$

Proof of Proposition 9. The maps $\mu \mapsto \alpha^*(\mu)$ and $F^*(\mu)$ are continuous on $[\bar{p}, p)$, being projections of continuous functions, so H is continuous. At $\mu = \bar{p}$, $H < 0$ because (B) fails; by (H), $H(\mu) > 0$ for μ close to p . The intermediate value theorem yields $\mu_h \in (\bar{p}, p)$ with $H(\mu_h) = 0$, so the low type is indifferent between pooling and its fair token sale, and σ_h solves $\mu(\sigma_h) = \mu_h$; $\sigma_h \in (0, 1)$ since $\mu_h \in (\bar{p}, p)$. The high type's optimality follows as in Proposition 4, using $\frac{p-q}{q}\tau_q \geq m(\mu_h)\tau_{\mu_h}$ and $\frac{p-q}{q} \geq m(\mu_h)$, together with the feasibility hypothesis. If $F^*(\mu_h) = K$, Lemma 3 applies to every deviation, and the argument of Proposition 8 gives survival under D1. $\square$

Proof of Proposition 10. The objective is $\Gamma_\lambda(\alpha) = m \max\{I - K, \tau(\alpha)\} + \lambda\tau(\alpha) - pA(1 - \kappa)\alpha$. On $[0, \alpha_K]$ it equals $m(I - K) + \lambda\tau - pA(1 - \kappa)\alpha$, which is convex with stationary point α_λ . On $[\alpha_K, \alpha^{\max}]$ it equals $(m + \lambda)\tau - pA(1 - \kappa)\alpha$, which is convex with stationary point $\hat{\alpha}_\lambda \leq \alpha_\lambda$. At α_K the right derivative exceeds the left by $m\tau'(\alpha_K) \geq 0$, so Γ_λ is convex on $[0, \alpha^{\max}]$. If $\alpha_\lambda \leq \alpha_K$, the minimizer is α_λ^+ , since the derivative is non-negative on $[\alpha_K, \alpha^{\max}]$. If $\alpha_\lambda > \alpha_K$, the minimizer is $\max\{\alpha_K, \hat{\alpha}_\lambda\}$. Both cases are captured by (20), capped at $\alpha^{\max}$. For $I > K$, $\alpha_K > 0$, and tokens are issued if and only if the derivative at 0 is negative, $\lambda\tau'(0) < pA(1 - \kappa)$, which is (T). $\square$

Proof of Proposition 11. Debt with face value at most $K + (1 - \varphi)A_B(L + \alpha)$ pays D on success and $\min\{D, K\}$ on failure for both types. Its value is type-independent, and the bound on I ensures that such debt can raise the required amount. Equity in the residual pays $s(K + (1 - \varphi)A_B(L + \alpha) - D)$ on success, which is type-dependent and underpriced for the high type under pooling, so it is strictly dominated by debt. Tokens are priced at $\bar{A}$, so the high type's payoff is $K - I + pA_G(L + \alpha) - p(A_G - \bar{A})\alpha(L + \alpha)/\bar{N}$, which is strictly concave in α with stationary point $\frac{1}{2}(A_G\bar{N}/(A_G - \bar{A}) - L)$, independent of I . Under the stated condition the stationary point is non-positive. If both types pool on debt alone, the low type obtains $K - I + pA_B L$, since debt is fairly priced, whereas a fair token sale yields $K - I + pA_B(L + \alpha_B^{\max})$; pooling therefore fails. $\square$

Proof of Lemma 4. As in Lemma 1, exact raising at success probability $\mu + r\alpha$ gives $S - F = (I - F)/(\mu + r\alpha)$. Then

$$p_\theta(\alpha)S + (1 - p_\theta(\alpha))F = I + (p_\theta - \mu)(S - F) = I + \frac{p_\theta - \mu}{\mu + r\alpha}(I - F),$$

and $U_\theta = K + p_\theta(\alpha)W(\alpha) - [\cdot]$ yields the claim. $\square$

Proof of Proposition 12. Lemma 2 applies with τ^r , so the high type sets $I - F = \max\{I - K, \tau^r(\alpha)\}$, and debt dominates equity as in Proposition 2. Relative to $K - I + pAL$, the objective to be minimized is

$$\Gamma_r(\alpha) = \frac{p - \bar{p}}{\bar{p} + r\alpha} \max\{I - K, \tau^r(\alpha)\} - pA\alpha - r\alpha A(L + \alpha).$$

On $[0, \alpha_K^r]$, the first term equals $(p - \bar{p})(I - K)/(\bar{p} + r\alpha)$, which is non-increasing in α , and the remaining terms are strictly decreasing, so Γ_r is strictly decreasing. On $[\alpha_K^r, \alpha_r^{\max}]$, the first term equals $(p - \bar{p})\alpha A(L + \alpha)/\bar{N}$, so

$$\Gamma_r(\alpha) = g_r(\alpha) \equiv A\alpha \left[\frac{(p - \bar{p} - r\bar{N})(L + \alpha)}{\bar{N}} - p \right].$$

If $p - \bar{p} > r\bar{N}$, g_r is strictly convex with stationary point $\hat{\alpha}_r$, and the argument of Proposition 2 gives the first case. If $p - \bar{p} \leq r\bar{N}$, the bracket is negative for all $\alpha \geq 0$ and $g'_r(\alpha) = A[(p - \bar{p} - r\bar{N})(L + 2\alpha)/\bar{N} - p] < 0$, so g_r is strictly decreasing and $\alpha_r^* = \alpha_r^{\max}$. Part (i) rearranges Condition A_r ; part (ii) follows because $\hat{\alpha}_r > 0$ when Condition A_r fails, so $\alpha_r^* > 0$ even if $\alpha_K^r = 0$; part (iii) is the second case. $\square$

Proof of Proposition 13. *High type.* A deviation priced at q costs, relative to $K - I + pAL$, at least $\Gamma_r^q(\alpha) = \frac{p-q}{q+r\alpha} \max\{I - K, \tau_q^r(\alpha)\} - pA\alpha - r\alpha A(L + \alpha)$. Termwise, $\frac{p-q}{q+r\alpha} \tau_q^r(\alpha) = (p - q)\alpha A(L + \alpha)/\bar{N} \geq (p - \bar{p})\alpha A(L + \alpha)/\bar{N} = \frac{p-\bar{p}}{\bar{p}+r\alpha} \tau^r(\alpha)$, and $(p - q)(\bar{p} + r\alpha) > (p - \bar{p})(q + r\alpha)$ gives $\frac{p-q}{q+r\alpha} > \frac{p-\bar{p}}{\bar{p}+r\alpha}$. Hence $\Gamma_r^q \geq \tilde{\Gamma}_r$, the pooled objective without the feasibility constraint, whose minimizer is feasible by hypothesis; the high type does not deviate. *Low type.* By Lemma 4, pooling gives $K - I + (q + r\alpha_r^*)A(L + \alpha_r^*) + \frac{\bar{p}-q}{\bar{p}+r\alpha_r^*}(I - F_r^*)$, and a fairly priced deviation gives $K - I + (q + r\alpha')A(L + \alpha')$, which is maximized at $\alpha_{r,q}^{\max}$. The low type does not deviate if and only if (B_r) holds, and pessimistic beliefs make the condition necessary. $\square$

Proof of Lemma 5. Investors price the high type's contract at success probability $p + r_G\alpha$, so exact raising gives $S - F = (I - F)/(p + r_G\alpha)$. The low type's expected payment to investors is $F + (q + r_B\alpha)(S - F) = I - [(p - q) + (r_G - r_B)\alpha](I - F)/(p + r_G\alpha)$. Its payoff from mimicking, net of $K - I$, is therefore $V_B(\alpha) + [(p - q) + (r_G - r_B)\alpha](I - F)/(p + r_G\alpha)$. With safe debt for the remainder and $I \leq K$, $I - F$ equals token proceeds $(p + r_G\alpha)\alpha A(L + \alpha)/\bar{N}$, so the subsidy is

$[(p - q) + (r_G - r_B)\alpha]A(L + \alpha)/\bar{N}$. Subtracting $V_B(0) = qAL$, the payoff from safe debt alone, and dividing by $A\alpha$ gives ψ . Monotonicity is immediate since $r_B \geq 0$ and $r_G \geq r_B$. $\square$

Proof of Theorem 2. Because V_θ is convex, type θ 's fair-price optimum over $[0, \alpha_\theta^{\max}]$ is 0 or $\alpha_\theta^{\max}$. For the low type, $V_B(\alpha_B^{\max}) > V_B(0)$ if and only if $\omega < \omega_B$. In any separating PBE the low type's contract is fairly priced, and it can secure at least its fair price on any contract, since beliefs put probability at most one on the low type; hence it plays its fair-price optimum.

(i) If $\omega < \omega_B$, the low type sells $\alpha_B^{\max}$. The high type's tokens satisfy $\alpha_G \leq \alpha_G^{\max} \leq \alpha_B^{\max}$. If $\alpha_G = \alpha_B^{\max}$, mimicking gives the low type the same users and a strictly positive subsidy on the tokens, contradicting incentive compatibility; hence $\alpha_G < \alpha_B$.

(ii) If $\omega > \omega_B$, the low type's fair-price optimum is 0, so $\alpha_B = 0$, and any $\alpha_G > 0$ separates.

(ii)(a) *Equilibrium.* Let the high type issue $\bar{\alpha} = \bar{\alpha}(\omega)$ tokens plus safe debt, let the low type issue safe debt alone, and let off-path beliefs be pessimistic. The low type does not mimic, since its gain is $A\bar{\alpha}\psi(\bar{\alpha}) \leq 0$; it does not prefer another fairly priced contract, since $\omega > \omega_\psi \geq \omega_B$. The high type does not prefer safe debt, since $V_G(\bar{\alpha}) > V_G(0)$, nor any pessimistically priced deviation, by hypothesis. *Intuitive Criterion.* Priced at the high type's valuation, a deviation gives the high type $K - I + V_G(\alpha')$, independently of the split between debt and other claims. For $\alpha' \leq \bar{\alpha}$, convexity gives $V_G(\alpha') \leq \max\{V_G(0), V_G(\bar{\alpha})\} = V_G(\bar{\alpha})$, so the high type does not gain. For $\alpha' \in (\bar{\alpha}, \alpha_G^{\max}]$, $\psi(\alpha') > 0$, so the low type gains from the deviation at that price with a safe-debt remainder, and a fortiori with riskier claims, which carry a larger subsidy. No deviation benefits only the high type. *Uniqueness.* If a separating PBE has $\alpha_G < \bar{\alpha}$, convexity and $V_G(\bar{\alpha}) > V_G(0)$ give $V_G(\alpha_G) < V_G(\bar{\alpha})$; by continuity some $\alpha' < \bar{\alpha}$ close to $\bar{\alpha}$ has $V_G(\alpha') > V_G(\alpha_G)$ and $\psi(\alpha') < 0$. This deviation strictly benefits the high type and strictly hurts the low type at every belief, so the Intuitive Criterion eliminates the equilibrium. The same deviation eliminates pooling on safe debt. Equilibria with $\alpha_G > \bar{\alpha}$ violate the low type's incentive constraint.

(ii)(b) If $\omega_B < \omega \leq \omega_\psi$, then $\psi(0) \geq 0$ and $\psi(\alpha) > 0$ for all $\alpha > 0$: the low type would mimic any high-type token sale, so $\alpha_G = 0$ in any separating PBE. In pooling on safe debt, any deviation that benefits the high type at its valuation has $\alpha' > 0$ and also benefits the low type, so pooling survives. $\square$

Proof of Corollary 3. The function ψ is continuous, increasing in α and decreasing in ω , with $\psi(0) = 0$ at $\omega = \omega_\psi$; hence $\bar{\alpha}(\omega)$ is non-decreasing and $\bar{\alpha}(\omega) \downarrow 0$ as $\omega \downarrow \omega_\psi$. By convexity, $V_G(\bar{\alpha}) > V_G(0)$ if and only if $\omega < A[p + r_G(L + \bar{\alpha})]$. As $\omega \downarrow \omega_\psi$, this requires $\omega_\psi < A(p + r_GL)$, which rearranges to (GN); when (GN) holds, continuity yields an interval $(\omega_\psi, \omega_\psi + \epsilon)$. Since $\bar{\alpha} \leq \alpha_G^{\max}$, the good-news region is non-empty only if $\omega_\psi < A[p + r_G(L + \alpha_G^{\max})]$, which gives the necessary condition. Parts (a)–(c) follow by inspection, using that Condition A implies $\bar{N} < L$. $\square$

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