Harnessing the Overconfidence of the Crowd: A Theory of SPACs

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Abstract

We provide a theory of Special Purpose Acquisition Companies, or SPACs. A sponsor raises financing for a new opportunity from a group of investors with differing ability to process information. We show that when all investors are rational, the sponsor prefers to issue straight equity. However, when sufficiently many investors are overconfident about their ability to process information, the sponsor prefers to issue units with redeemable shares and rights. The model matches many empirical features, including the difference in returns for short-term and long-term investors and the overall underperformance of SPACs. We also evaluate the impact of policy interventions, such as greater mandatory disclosure and transparency, limiting investor access, and restricting the rights offered.

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1 Introduction

A SPAC (Special Purpose Acquisition Company) or "blank check company" raises financing via an initial public offering in order to merge with a private target and take it public. The SPAC raises capital by selling units, which consist of redeemable shares and derivative securities (e.g., warrants or rights) that allow the holder to buy additional shares at a future date. The SPAC sponsor is tasked with identifying a target firm within a specified period and is compensated with an allocation of equity.[1] Investors have the option to redeem their shares at the initial issue price if they do not approve of the proposed target, and are allowed to keep their rights and warrants even after redemption.

Despite the complex nature of these transactions, the recent boom in SPAC deals has been extraordinary. In the first eight months of 2021 alone, there have been 419 SPAC IPOs in the US that raised over $122 billion.[2] This corresponds to 63% of the total number of IPOs over the period, and around 44% percent of the proceeds of all IPO transactions. This boom in transactions belies the mixed performance for SPAC investors. On the one hand, Gahng, Ritter, and Zhang (2021) estimate that investors who buy shares at the SPAC IPO and redeem optimally before the merger earn average annualized returns of 9.3%, on an essentially risk-free investment.[3] On the other hand, investors who buy and hold shares in the merged company earn one-year buy and hold returns of -15.6%. The redemptions also lead to substantial dilution: Klausner and Ohlrogge (2020) show that for every $10 raised from investors at the IPO, the median SPAC only holds $6.67 in cash for each outstanding share at the time of the merger. Moreover, SPAC shares tend to drop by one third of their value within a year following the merger.

Given this evidence, the popularity of SPAC transactions is extremely puzzling. Since investors can redeem their shares at the issue price *and* keep their rights or warrants at no cost, optimal redemption strategies generate large profits for short-term investors at the expense of sponsors and long-term investors. Why would a sponsor *choose* to raise financing using a SPAC transaction when doing so leads to such substantial dilution of their stake? What types of firms prefer to go public via a SPAC transaction instead of a standard IPO? And why do long term investors buy and hold shares in SPACs given their poor performance?

We propose a model of SPACs that helps resolve these puzzles. The key insight is that while redeemable shares dilute the sponsor's stake when all investors are rational, they

[1] This equity allocation is called the sponsor promote, and is typically around 20% of the shares.

[2] For comparison, there were a total of 248 SPAC IPOs in 2020, raising around $83 billion in proceeds, while the total number of SPAC IPOs between 2003 and 2019 was 388 and the total issuance over these years was around $70 billion. See https://www.spacanalytics.com and https://spacinsider.com/stats/.

[3] The proceeds of the SPAC are held in an escrow account, and are usually invested in money-market securities such as T-Bills.

can be used to exploit the over-confidence of unsophisticated, retail investors. Intuitively, when retail investors over-estimate their ability to process information, they overvalue the optionality embedded in redeemable shares which leads to over-pricing. As such, when the proportion of such unsophisticated investors is sufficiently high, the sponsor prefers financing the project using redeemable shares rather than straight equity. We show that SPAC financing is preferred for investment opportunities that are risky and positively skewed, and require an intermediate level of initial financing. Our model matches key stylized facts: (1) buy-and-hold investors earn negative returns while those redeeming optimally earn excess returns, (2) higher redemptions predict lower returns, and (3) firms choosing SPACs are riskier and have less tangible and more skewed payoffs.

Our model also provides a benchmark for policy analysis. This recent boom in SPAC deals and their severe under-performance for buy-and-hold investors has led to scrutiny by regulators and calls for changes to disclosure requirements and investor protection.[4] For instance, in a letter to Congress, Americans for Financial Reform and Consumer Federation of America argue that:[5]

> The growth in SPACs represents attempts by sponsors and their targets to end-run longstanding rules designed to promote fair and efficient markets, and exposes investors and our markets to significant risks. These investors, many of whom are retail investors, [...] are likely unaware of the complexity of fee arrangements or the expected dilution that will eventually erode the value of their investments.

We explore the impact of several proposed policies. For instance, restricting investor access by sophistication (e.g., by only allowing accredited investors to participate), leads to better returns for buy-and-hold investors but lower returns for short–term investors. Similarly, restricting or eliminating rights as part of the initial unit issuance leads to lower over-pricing, and consequently higher returns for buy-and-hold investors.

Interestingly, we show that mandatory disclosure and transparency can have different effects on investor returns. Instead of "leveling the playing field," an increase in mandatory disclosure (e.g., increasing the precision of available information) can lead to *lower* returns for retail investors, especially when the mass of such investors is sufficiently high. In contrast, we show that an increase in transparency (e.g., due to a reduction in information processing costs) improves returns for retail investors and, as such, may be more effective at reducing

[4]See, for example, https://www.barrons.com/articles/spacs-ipos-sec-regulation-gensler-51624469993 and SEC Investor Alerts titled "Celebrity Involvement with SPACs" (March 10, 2021) and "What You Need to Know About SPACs" (May 25, 2021).

[5]See "Letter Urging Congress to Address Risks in Growing SPAC Mania," February 16, 2021 (https://ourfinancialsecurity.org/2021/02/letters-to-congress-letter-urging-congress-to-address-risks-in-growing-spac-mania/).

the discrepancy in investor returns.

Overview of model and results. Section 3 presents the model. A sponsor wishes to raise a fixed amount of capital to finance a new investment opportunity. She chooses between issuing non-redeemable shares (e.g., in an IPO) or units consisting of redeemable shares bundled with rights to new shares (as in a SPAC).[6] There is a continuum of risk neutral investors who can provide (up to) a fixed amount of capital. A fraction of these investors are sophisticated, institutional investors, while the rest are unsophisticated, retail investors.

Before the investment opportunity is undertaken, interim information about the profitability of the opportunity becomes available. Paying attention to, and processing, this information is costly. Sophisticated investors have an advantage at processing this interim information and so optimally choose to redeem their shares when the news is sufficiently bad. However, unsophisticated investors are unable to process the interim information and so hold on to their shares irrespective of the news.

Section 4 presents the benchmark analysis. Our main result characterizes the optimal form of issuance chosen by the sponsor. When unsophisticated investors correctly anticipate that they will not process interim information, the sponsor optimally chooses to raise financing using non-redeemable shares. However, when unsophisticated investors are overconfident about their ability to process interim information, we show that the sponsor may find it optimal to issue units with redeemable shares and equity rights.

To gain some intuition, note that the sponsor faces the following tradeoff when issuing redeemable units. On the one hand, for every dollar of capital required for investment, she needs to raise more than a dollar of financing initially to account for possible redemptions by sophisticated investors. This "financing multiplier" increases the cost of issuing redeemable units relative to standard, equity financing. On the other hand, when unsophisticated investors are overconfident, they over-estimate the likelihood they will redeem their shares in the future, and so are willing to overpay for this real option initially. This equilibrium "overpricing" decreases the (relative) cost of issuing redeemable units. When the mass of unsophisticated investors is sufficiently large, we show that the overpricing effect dominates and the sponsor prefers the SPAC to the standard IPO.

Our benchmark analysis matches a number of stylized facts about SPACs. We show that while sophisticated investors who optimally redeem their shares earn positive returns, unsophisticated investors who do not redeem their shares earn negative returns. The sponsor is more likely to pursue a SPAC transaction when the investment opportunity is riskier, which

[6] In practice, sponsors also issue units consisting of redeemable shares and warrants. We study warrants in Section 6.3 and show that our results extend to this case.

leads to lower returns for both sophisticated and unsophisticated investors. The expected payoff to the sponsor from a SPAC increases with the mass of unsophisticated investors, and with investor wealth, when the mass of sophisticated investors is sufficiently large. This helps explain the rapid increase in the popularity of SPAC transactions since 2020, which saw a sharp increase in retail investor participation in financial markets (e.g., Ozik, Sadka, and Shen (2020)).

Policy implications and Extensions. In our benchmark analysis, the use of a SPAC transaction affects the division of surplus between the sponsor and the investors, but does not affect the expected value of the project and so leaves the total surplus unchanged. In Section 5, we extend the model to allow the sponsor to exert costly effort to improve the average payoff of the investment opportunity (e.g., by engaging in costly search to identify more profitable targets). We characterize conditions under which the sponsor exerts effort only if she can finance the opportunity using a SPAC but not if she is restricted to using non-redeemable shares. In this case, if the resulting improvement in average payoffs is sufficiently high, allowing for SPAC transactions improves social surplus.

This extension allows us to consider the impact of recent proposals for regulatory interventions. For instance, given the negative returns to unsophisticated, buy and hold investors, one might wish to restrict access to SPAC transactions based on measures of sophistication (e.g., by only allowing accredited investors to invest in them). Another proposal is to "level the playing field" by increasing mandatory disclosures.[7] We show that such interventions may have unintended consequences. For instance, we show that restricting investor access to SPACs based on sophistication or restricting the maximum stake per investor in the SPAC serves to improve returns for unsophisticated investors, but reduces returns for sophisticated investors and decreases the surplus that accrues to the sponsor. To the extent that this drop in sponsor surplus leads to lower effort, such interventions can reduce total surplus. Similarly, an increase in the quality of interim information (e.g., due to increased mandatory disclosure) improves returns for sophisticated investors, but reduces sponsor payoffs and can reduce returns for unsophisticated investors, especially when the fraction of such investors is large.

In Section 6.1, we extend the benchmark model to allow the sponsor to raise capital from an outside investor after redemptions by sophisticated investors in a Private Investment in Public Equity, or PIPE, transaction. PIPE investments from institutional investors are extremely common in SPAC transactions - Klausner and Ohlrogge (2020) estimate that

[7] See e.g. https://consumerfed.org/wp-content/uploads/2021/02/AFR-Letter-on-SPACs-to-HFSC.pdf and https://www.sec.gov/news/public-statement/spacs-ipos-liability-risk-under-securities-laws.

around 25% of the cash at the time of the merger is from such investors. PIPE financing is often argued to be beneficial for common SPAC investors. First, it helps cover the cash short-fall due to redemptions, and thus help increase the likelihood of a successful merger. Second, many sponsors argue that participation by such investors can act as a “stamp of approval” for the proposed deal, since PIPE investors tend to be sophisticated and well informed.

In our model, while raising PIPE financing reduces the impact of redemptions, it introduces a new tradeoff for the sponsor. Since the PIPE investor is informed and the sponsor raises more PIPE financing after bad news, bargaining leads to more dilution for the sponsor, lowering her surplus. On the other hand, by raising some of the financing from PIPE investors, the sponsor can target more overconfident investors, which leads to more over-pricing and higher sponsor surplus. We show that the optimal level of PIPE financing increases with the bargaining power of the sponsor and the probability of redemptions, but decreases with the mass of unsophisticated investors. Moreover, we find that the return to unsophisticated investors decreases in the level of PIPE financing, which suggests that the impact of such financing on investors is more nuanced than commonly suggested.

In Section 6.2, we characterize how the sponsor’s optimal financing choice depends on the attention and processing costs for unsophisticated investors. When attention costs are sufficiently low, all investors process the interim information, so the sponsor strictly prefers to raise financing using non-redeemable shares. When attention costs are sufficiently high, none of the unsophisticated investors process the interim information, and so our benchmark analysis applies: the sponsor prefers a SPAC issuance when the fraction of unsophisticated investors is sufficiently large. For intermediate levels, we show that the sponsor offers a contract with redeemable shares and rights which leaves the unsophisticated investors indifferent between paying the attention cost (and optimally redeeming their shares) or not. As in the benchmark, we show that the sponsor prefers this contract to financing via non-redeemable shares when the mass of unsophisticated investors is sufficiently large. Moreover, we show that the return to unsophisticated investors decreases in their cost of information processing, while the return to sophisticated investors increases in it. This suggests that increases in transparency, which reduce the cost of processing interim information for unsophisticated investors, has different implications than increases in amount or precision of the interim information.

The rest of the paper is as follows. The next section provides a brief discussion of the related literature. Section 3 introduces the model and provides a discussion of the key assumptions. Section 4 provides the main analysis of the paper, by characterizing conditions under which the sponsor optimally offers units with redeemable shares and describing features of the optimal contract. Section 5 considers the impact of policy interventions in an extension of the benchmark model which incorporates the impact of sponsor effort. Section 6 considers the impact of PIPE financing, and the extension to costly information processing by retail investors. Section 7 concludes. Unless mentioned otherwise, all proofs are in the Appendix.

2 Related Literature

The primary contribution of our paper is to provide a benchmark model of SPACs. While there is a growing empirical literature that documents the performance and characteristics of SPACs, theoretical analysis of these transactions is sparse.[8] The closest paper is Bai, Ma, and Zheng (2020), who model SPACs as certification intermediaries. They consider firms which differ in both risk and average return and choose whether to go public via IPO or via a SPAC. In their model, SPACs are valuable because the sponsor's promote incentivizes costly screening effort, and the market is segmented: riskier firms choose SPACs while safer ones choose IPOs. However, because their model does not feature redemptions, it is unable to speak to a key feature of SPAC transactions. Our analysis, which we view as complementary, provides an explanation for why sponsors find it optimal to issue units with redeemable shares. By focusing on investor overconfidence, our model generates unique policy predictions, e.g., improved disclosure may reduce investors' returns and restricting access to sophisticated investors has positive spillovers.

Chatterjee, Chidambaran, and Goswami (2016) apply the model of Chemmanur and Fulghieri (1997) to SPACs. Sponsors issue units consisting of equity and warrants to risk-averse investors under adverse selection, and the warrant portion signals their type. Since all investors are rational, their framework cannot generate the significantly negative returns for retail investors documented by Gahng et al. (2021). Our model does not rely on adverse selection, and the sponsor issues redeemable shares to exploit retail investors' overconfidence instead. This generates the return patterns observed in reality.

The redeemable shares in our framework are reminiscent of the mechanism design literature on sequential screening (i.e. Davis (1995), Che (1996), Courty and Hao (2000), and Krähmer and Strausz (2015)). In these papers, a principal allows a customer to return a product for a *partial* refund. Both the refund and the ex-ante price are then used to screen the customer's type. These models cannot explain SPACs, because (i) in a SPAC, investors can return their shares for a *full* refund and keep their rights (i.e. they keep part of the

[8]See Lewellen (2009), Jenkinson and Sousa (2011), Cumming, Haß, and Schweizer (2014), Kolb and Tykvova (2016), Dimitrova (2017), Shachmurove and Vulanovic (2017), Vulanovic (2017), and more recently Klausner and Ohlrogge (2020) and Gahng et al. (2021).

"product"), which is suboptimal in these papers, (ii) the SPAC is sold on a public market for a fixed price; thus neither the ex-ante price nor the refund is not used to screen, (iii) SPACs have significantly negative returns to investors who keep their shares, whereas agents are rational in these models and earn positive rents.[9]

More broadly, our paper contributes to the literature on behavioral contracting and overconfidence.[10] Our main insight is that with enough investor overconfidence, the sponsor finds it optimal to raise financing using redeemable shares, even though in principle, this leads to more dilution. The key mechanism is that when investors are overconfident about their ability to acquire information in the future, they overestimate the option value of redeeming shares, and so are willing to pay more for them. To our knowledge, this connection is absent from the behavioral contracting literature.

Finally, our model is related to the literature on book-building in IPOs (i.e. Sherman (2000), Sherman and Titman (2002), and Sherman (2005)). Consistent with these papers, we study security issuance as an optimal contracting problem, and the sponsor faces both sophisticated and unsophisticated investors.[11] Unlike these papers, our model features overconfidence and the optimal contract consists of redeemable shares.

3 Model

Payoffs. There are three dates $t \in \{1, 2, 3\}$. A sponsor (S, she) has an investment opportunity that costs K in external financing. The investment, or project, has a terminal (date three) payoff $V \in \{l, h\}$, where $h > l > 0$ and $\mu_0 \equiv \Pr(V = h)$. The unconditional mean and variance of V are given by

$$V_0 = \mu_0 h + (1 - \mu_0)\, l \text{ and } \sigma_V^2 = \mu_0 (1 - \mu_0)(h - l)^2 .$$

To distinguish the impact of changes in payoffs from changes in μ_0, we refer to an increase in V_0 holding fixed μ_0 as an increase in the *level of payoffs* and an increase in σ_V^2 holding fixed μ_0 as a *mean preserving spread*.

The unconditional expected payoff is higher than the cost of financing i.e., $V_0 > K$, which ensures that the project can be financed by selling straight equity. The sponsor retains one

[9] That is, if we understand investors' outside option as the risk-adjusted rate of return, investors would earn excess returns in equilibrium. Instead, buy-and-hold investors earn negative returns in a SPAC.

[10] See e.g. Manove and Padilla (1999), Gervais and Odean (2001), Scheinkman and Xiong (2003), DellaVigna and Malmendier (2004), Eliaz and Spiegler (2006), Sandroni and Squintani (2007), Eliaz and Spiegler (2008), Landier and Thesmar (2008), Heidhues and Koszegi (2010), Gervais, Heaton, and Odean (2011), and Spinnewijn (2013).

[11] See also Benveniste and Spindt (1989) and Benveniste and Wilhelm (1990).

share of equity and raises financing at date one by selling E units to investors at price P per unit.[12] Each unit consists of one redeemable share of equity and r rights, where each right endows the owner with an additional share of equity. Shares can be redeemed at date two at price P, and investors who redeem their shares keep all of their rights.[13]

Investors. There is a continuum of risk-neutral investors, indexed by $i \in [0, 1]$, each with wealth $W > K$.[14] Each investor is either an institutional or a retail investor, and the fraction of retail investors is $m \in [0, 1]$. With slight abuse of notation, we use $i = I$ to denote institutional investors and $i = R$ to denote retail investors. At date one, given the sponsor's offered contract (E, r, P), investor i chooses the optimal number $e_i \geq 0$ of units to buy at date one given wealth W.

At date two, investors have access to interim private information about terminal payoffs, but we assume that paying attention to (and processing) this information is costly. Specifically, investor $i \in \{I, R\}$ chooses whether or not to acquire (denoted by $a_i \in \{0, 1\}$) a private signal $x_i \in \{l, h\}$ about the the project payoff V by incurring attention cost c_i, where

$$\Pr\left(x_i = h | V = h\right) = 1, \quad \Pr\left(x_i = l | V = l\right) = \gamma. \tag{1}$$

Conditional on V, x_i are independent across investors. Let $V_x \equiv \mathbb{E}\left[V | x_i = x\right]$ denote the conditional expected payoff if investor i observes $x_i = x$. Then,

$$V_h = \frac{\mu_0}{\mu_0 + (1 - \mu_0)(1 - \gamma)}(h - l) + l, \quad \text{and } V_l = l,$$

since $x_i = l$ is fully revealing. Moreover, denote the unconditional likelihood of high signal by $q \equiv \Pr\left(x = h\right) = \mu_0 + (1 - \mu_0)(1 - \gamma)$.

Given this information, each investor chooses whether to keep the shares (denoted by $k_i = 1$) or redeem them ($k_i = 0$).[15] If investor i does not acquire the signal, they keep the shares they own by default (i.e., $k_i = 1$).[16] Consistent with empirical evidence, we assume

[12]Note that in practice, SPAC shares are usually issued at \$10 per share, but the eventual terms of the merger / acquisition determine an implicit price per share. We capture this relative effect by allowing the price P to change. Allowing the sponsor to choose how many shares to retain does not alter any of the results. If the sponsor chooses to retain s shares, then we can simply scale the number of shares and rights issued by s.

[13]An equity right is equivalent to a warrant with a strike price of zero. In Section 6.3, we study warrants with arbitrary strike prices and show that our results go through, i.e. issuing units consisting of redeemable shares and warrants is optimal.

[14]This ensures that, in the aggregate, investors have sufficient wealth to finance the project.

[15]Conditional on x_i, it is optimal for each investor to either redeem all shares or to keep all of them. Thus, we do not need to consider investors keeping a fraction of their shares and redeeming the rest.

[16]This captures the feature that investors exhibit inertia in their portfolio decisions, consistent with the

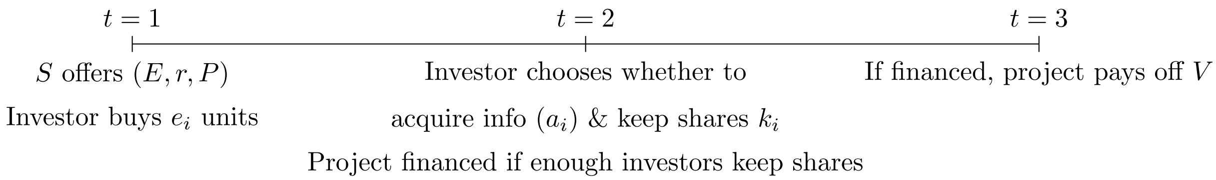

Figure 1: Timeline

that it is cheaper for institutions to acquire and process information than it is for retail investors i.e., $c_I < c_R$ (e.g., see Engelberg (2008) and the survey by Blankespoor, deHaan, and Marinovic (2020)). For expositional clarity, we normalize $c_I = 0$, so that institutional investors always acquire information. In our benchmark analysis, we set c_R sufficiently high so that retail investors never acquire information, as summarized by the following condition.[17]

Assumption 1. *The cost of information acquisition for institutional investors is $c_I = 0$ and for retail investors is $c_R \geq \bar{c} \equiv (1-q)\,W$.*

More importantly, we assume that retail investors are overconfident in their ability to acquire information and differ in the extent of this overconfidence, which we parameterize by $\beta \in [0, 1]$. Specifically, at date one, a β-type retail investor is uncertain about their cost of information acquisition c_i and (incorrectly) believes that it will be $c_i = c_I$ with probability β and $c_i = c_R$ with probability $1 - \beta$. Thus, at date one, β-type retail investors believe that they will acquire information with probability β, but they actually never acquire information at date two. As such, β is a measure of the retail **investors' overconfidence**: it measures the degree to which they underestimate their average cost of information acquisition, or equivalently, overestimate their propensity to acquire information at date two. We assume that retail investors differ in their degree of overconfidence and that β has a continuous distribution $G(\beta)$ for the continuum of retail investors.

Figure 1 summarizes the timing of events, which we describe below.

- Date one: The sponsor offers the contract (E, r, P). Investor i optimally chooses to buy e_i units at a price P, given their beliefs about future redemption decisions. The market clearing condition is given by

$$\int_i e_i di = E.$$

standard approach of modeling rational inattention (e.g., Sims (2003), Sims (2006), Steiner, Stewart, and Matejka (2017)). We abstract from investors selling shares on the open market, since this does not affect the sponsor's financing constraint or payoff.

[17] We relax this assumption in Section 6.2, and characterize the impact of c_R on the equilibrium.

- Date two: Investor i chooses whether to pay cost c_i to observe signal x_i. If investor i acquires information, they choose whether to keep their shares ($k_i = 1$) or redeem them ($k_i = 0$). The project is financed if a sufficiently large number of investors choose to keep their equity invested in the project, i.e., if[18]

$$P \int_i e_i k_i di \geq K. \tag{2}$$

- Date three: If the project is successfully financed at date two, it pays off V.

3.1 Discussion of assumptions

The key assumption for our analysis is that retail investors exhibit overconfidence. A large empirical literature finds evidence of these features in the data (see the recent survey Daniel and Hirshleifer (2015)). Specifically, our assumption is inline with the observation that retail investors over-estimate their ability to trade on profitable stocks (e.g., Odean (1999), Barber and Odean (2000)) and their ability to pick better performing active funds (e.g., French (2008), Malkiel (2013)), and with experimental evidence that suggests investors overestimate the precision of their signals (e.g., Biais, Hilton, Mazurier, and Pouget (2005)). We show that this overconfidence naturally leads to the optimality of issuing units with redeemable shares. Indeed, as we show in Section 4.1.3, the sponsor prefers to offer non-redeemable shares when retail investors are rational.

A number of our other assumptions are made for tractability and expositional clarity. For instance, we assume that redeemed shares are given to a third party, so that redemptions do not affect shares outstanding. This biases our model *against* issuing redeemable shares – when investors' redemptions reduce shares outstanding, they increase the sponsor's payoff, provided that the project is still financed. Then, the sponsor may benefit from inducing redemptions, whereas in our model, redemptions always hurt the sponsor. Similar assumptions are common in the literature (e.g. Benveniste and Spindt (1989) Sherman (2000), and Sherman and Titman (2002)) to avoid nonlinearities in investors' payoffs. In Appendix B.2, we relax this assumption and account explicitly for the fact that redemptions decrease the number of shares outstanding. While the setting is not tractable analytically, we show numerically that issuing redeemable shares is still optimal for the sponsor.

The information structure specified in Equation (1) highlights the role of "false positives" in our setting, while maintaining tractability. The key friction is that investors may not

[18] In reality, the sponsor may make up shortfalls by raising additional financing. We consider this case in Section 6.1 and show that our results survive.

redeem their shares when the payoff is low and so the value of information is driven by the extent to which it is informative about low payoff state i.e., $V = l$. Our analysis can be extended to richer informational settings as long as the low payoff state is not perfectly revealed by the information.

In practice, SPAC units consist of equity, rights, and warrants, which allow the investor to acquire additional shares of equity at a fixed exercise price. In our model, this is equivalent to units that consist of equity, rights, and warrants with an exercise price of zero. We explicitly consider warrants with non-zero exercise price in Section 6.3, and find that our results are qualitatively similar. Since warrants may or may not be exercised, depending on the value and the strike price, the shares outstanding now depend on the value of the target. This precludes characterizing the sponsor's problem analytically. We instead provide numerical solutions, which show that issuing redeemable shares and warrants is optimal. This, with warrants, our model becomes less tractable, but our main results survive.

4 Analysis

We solve the model by working backwards, first describing the investors' decisions and then describing the sponsor's decisions.

Investors. At date two, investors choose whether to acquire costly information x_i, and then whether to keep their shares. Formally, given a (date one) position of e_i units and a cost c_i, investor i chooses $k_i(x) \in \{0,1\}$ and $a_i \in \{0,1\}$ to maximize:

$$U(e_i;c_i) = \max_{a_i, k_i(x)} \begin{array}{c} e_i a_i \left(\frac{(r+k_i(h))qV_h + (r+k_i(l))(1-q)V_l}{1+E(1+r)} - P\left(qk_i(h) + (1-q)k_i(l)\right)\right) \\ +e_i(1-a_i)\left(\frac{1+r}{1+E(1+r)}V_0 - P\right) - c_i a_i, \end{array}$$

subject to the budget constraint $e_i P \leq W$.

Given a signal x, the expected payoff from owning a unit is

$$\frac{1+r}{1+E(1+r)}V_x - P,$$

which includes the share and r rights, while the payoff from redeeming the equity and keeping the rights is

$$\frac{r}{1+E(1+r)}V_x.$$

Thus, conditional on observing x, an investor keeps their shares (i.e., $k_i(x) = 1$) if and only if

$$\frac{1}{1+E\left(1+r\right)}V_x \geq P,$$

which depends on the price P, the amount of units issued E, and the amount of rights r. This reflects the assumption that redeemed shares are given to a third party, so that redemptions do not affect shares outstanding. As discussed in Section 3.1, this is for analytical tractability; we relax the assumption in Appendix B.2.

Now suppose that the price is such that

$$\frac{1}{1+E\left(1+r\right)}V_h \geq P \geq \frac{1}{1+E\left(1+r\right)}V_l. \tag{4}$$

We will show that this is true for the optimal contract. In this case, investors keep their shares if $x_i = h$ and redeem when $x_i = l$, i.e., $k_i\left(h\right) = 1$ and $k_i\left(l\right) = 0$. The value of acquiring a signal is given by the difference in payoffs from optimally redeeming shares versus keeping them irrespective of x, i.e.

$$\begin{aligned}\Delta_i &= e_i\left(\frac{\left(1+r\right)qV_h + r\left(1-q\right)V_l}{1+E\left(1+r\right)} - Pq\right) - e_i\left(\frac{1+r}{1+E\left(1+r\right)}V_0 - P\right) \\ &= e_i\left(1-q\right)\left(P - \frac{1}{1+E\left(1+r\right)}V_l\right) \geq 0.\end{aligned} \tag{5}$$

Investor i acquires information (i.e., $a_i = 1$) whenever the incremental benefit from acquiring the signal exceeds the cost i.e., $\Delta_i \geq c_i$. Assumption 1 ensures that the institutional investors always acquire information and that the retail investors never acquire information.

At date one, investor i chooses how many units e_i to buy to maximize their expected date two payoff $U\left(e_i; c_i\right)$. Since investors are risk neutral, they either invest all their wealth in the project or none, i.e., they optimally choose $e_i \in \{0, W/P\}$. Institutional investors correctly anticipate their cost of information and thus choose

$$e_I = \arg\max_{e_i \in \{0, W/P\}} U\left(e_i; c_I\right).$$

Institutional investors buy $e_I = W/P$ units at date one, since their per-unit expected payoff is always positive, i.e.

$$\frac{\left(1+r\right)qV_h + r\left(1-q\right)V_l}{1+E\left(1+r\right)} - Pq \geq 0. \tag{6}$$

However, retail investors are overconfident in their ability to acquire information. Formally, a β-type retail investor chooses to buy $e_R(\beta)$ units, where

$$e_R(\beta) = \arg\max_{e_i \in \{0, W/P\}} \beta U(e_i; c_I) + (1-\beta) U(e_i; c_R). \tag{7}$$

This implies that a β-type retail investor buys units if and only if

$$\beta \left(\frac{(1+r) q V_h + r(1-q) V_l}{1 + E(1+r)} - Pq \right) + (1-\beta) \left(\frac{1+r}{1+E(1+r)} V_0 - P \right) \geq 0. \tag{8}$$

The expected per-unit payoff is increasing in β and decreasing in P, all else equal. This implies that for a given price, there is a threshold type $\bar{\beta}$ such that all retail investors with $\beta \geq \bar{\beta}$ buy $e_R(\beta) = W/P$ units, while retail investors with $\beta < \bar{\beta}$ do not participate. As a result, only a fraction $1 - G(\bar{\beta})$ of retail investors buy units at date $t = 1$. Importantly, the per-unit payoff in Equation (8) is the *perceived* expected payoff for a retail investor at date one, and reflects the degree of overconfidence β. At date two, retail investors (correctly) realize that their cost is $c = c_R$ and optimally choose not to acquire information or redeem their shares. As a result, their expected date two payoff is $(1+r)V_0/(1+E(1+r)) - P$.

Sponsor. Now, consider the sponsor's financing decision at date two. Generically, the financing game has multiple equilibria. For instance, there always exists an equilibrium in which investors redeem their shares, irrespective of their information, and the project is never financed. We instead focus on equilibria in which (i) the project is financed, and (ii) all investors make optimal redemption decisions. In particular, while all participating retail investors keep their shares, institutional investors condition their redemption decisions on interim information. This implies that the financing condition is state dependent. When $V = h$, all institutional investors choose to keep their shares and so the financing condition is given by

$$1 - m + m\left(1 - G(\bar{\beta})\right) \geq K/W.$$

However, when $V = l$, a fraction γ of institutional investors observe $x_i = l$ and choose to redeem their shares. This implies that the financing condition is given by

$$(1-m)(1-\gamma) + m\left(1 - G(\bar{\beta})\right) \geq K/W. \tag{9}$$

The financing constraint is stricter when $V = l$, and so when Inequality (9) holds, the project is financed for any value V. We will focus on this case for the benchmark analysis. In Proposition 4, we provide conditions so that having the project always financed is optimal for the sponsor.

At date one, the sponsor's optimal choice of (E, r, P) maximizes the ex-ante value of her stake of the project, conditional on the project always being financed, i.e., it solves:

$$U_S = \max_{E,r,P} \frac{1}{1 + E(1+r)} V_0 \quad \text{subject to (4), (6), (8), (9),}$$

where Condition (4) ensures incentive compatibility for optimal redemption decisions, Conditions (6) and (8) ensure participation by institutional and retail investors at date one, and Condition (9) implies that the project is always financed.

4.1 Benchmarks

In this subsection, we characterize the optimal contract under special cases that provide natural benchmarks for the general analysis.

4.1.1 Non-redeemable units

First, suppose that the sponsor does not offer redeemable units. Then, investors cannot use interim information (i.e., the incentive compatibility condition in (4) does not apply) and all investors have the same expected payoffs at date $t = 1$, given by

$$U(e_i; c) = e_i \left(\frac{1+r}{1 + E(1+r)} V_0 - P \right).$$

The sponsor can ensure that all investors are willing to buy $e_i = W/P$ units by setting the price so that the above payoff is non-negative. Otherwise, no investor participates. Thus, the sponsor solves

$$U_S = \max_{E,r,P} \frac{1}{1 + E(1+r)} V_0 \text{ subject to } P \leq \frac{1+r}{1 + E(1+r)} V_0 \text{ and } EP \geq K,$$

which reflects the participation and financing constraints, respectively. When investors are indifferent, i.e., $P = \frac{1+r}{1+E(1+r)} V_0$, the financing constraint is given by

$$E \left(\frac{1+r}{1 + E(1+r)} V_0 \right) = K$$
$$\Leftrightarrow E(1+r) = \frac{K}{V_0 - K}.$$

This implies that the sponsor is indifferent between different values of (E, r) such that the above equation holds, and thus $r = 0$ is optimal without loss of generality. Then, the sponsor issues

$$E^{NR} = \frac{K}{V_0 - K}$$

shares and the following proposition characterizes the sponsor's optimal payoff.

Proposition 1. *If the sponsor sells non-redeemable shares, she does not grant any rights to investors and her optimal value is*

$$U_S^{NR} = V_0 - K. \tag{11}$$

The above result highlights that without redeemable shares, the sponsor does not benefit from bundling shares with rights. Since the unconditional expected payoff V_0 is assumed to be higher than the required level of financing K, i.e. $\mathbb{E}[V] > K$, financing the project with non-redeemable shares is always feasible and provides a natural benchmark for more sophisticated contracts.

4.1.2 Only institutional investors

Next, suppose that all investors are institutions i.e., $m = 0$. In this case, investors buy shares if the participation constraint (6) holds, or equivalently, if

$$P \leq \frac{1}{q}\frac{(1+r)\,qV_h + r\,(1-q)\,V_l}{1 + E\,(1+r)}.$$

This condition binds in the optimal contract, since any lower price leads to more dilution for the sponsor. Then, to ensure that investors keep the shares conditional on $x = h$ (i.e., the incentive compatibility condition (4) holds), we need

$$\begin{aligned} \frac{V_h}{1 + E\,(1+r)} &\geq P \\ \Leftrightarrow V_h &\geq \frac{1}{q}\left((1+r)\,qV_h + r\,(1-q)\,V_l\right), \end{aligned}$$

which is only possible if $r = 0$. In this case, the sponsor optimally issues no rights and sets

$$P = \frac{V_h}{1+E}.$$

Plugging this into the financing condition (9) and solving for the sponsor's optimal strategy gives us the following result.

Proposition 2. *With only institutional investors, the optimal contract with redeemable shares features $r = 0$. Moreover, if $(1-\gamma)\,V_h \geq V_l$, then investors keep their shares if*

$x = h$ and redeem if $x = l$ in the optimal contract, and the sponsor's optimal value is

$$U_S = V_0 - \frac{V_0}{V_h (1-\gamma)} K. \tag{12}$$

If $(1-\gamma) V_h < V_l$, then investors always keep their shares and the sponsor's optimal value is

$$U_S = V_0 - \frac{V_0}{V_l} K. \tag{13}$$

Furthermore, the sponsor strictly prefers selling non-redeemable shares than selling redeemable shares i.e., $U_S^{NR} = V_0 - K > U_S$.

With only institutional investors, offering redeemable shares is suboptimal for the sponsor. If $(1-\gamma) V_h \geq V_l$, investors redeem their shares when $x = l$ and the sponsor must raise additional cash to ensure that the project is financed, which dilutes her share. If $(1-\gamma) V_h \leq V_l$, investors always keep their shares, but the sponsor must underprice the shares to ensure that this is optimal for investors. In both cases, the contract selling non-redeemable shares yields a higher value for the sponsor.

4.1.3 No overconfidence

Now, suppose that retail investors do not exhibit overconfidence, and so correctly anticipate that they will not acquire information at date two (i.e., $G(0) = 1$). To ensure that retail investors invest in the project, the participation constraint (8) must hold for $\beta = 0$, or equivalently,

$$\frac{1+r}{1+E(1+r)} V_0 \geq P.$$

This also ensures that the institutional investors buy units at date one (i.e., their participation condition (6) holds). Moreover, the financing constraint (9) requires that

$$((1-m)(1-\gamma)+m) EP \geq K,$$

since $W = EP$. The sponsor then solves

$$\begin{aligned} U_S = \max_{E,r,P} \frac{1}{1+E(1+r)} V_0 &\text{ subject to} \\ EP \geq \frac{K}{(1-m)(1-\gamma)+m}, &\text{ and} \\ P \leq \frac{1+r}{1+E(1+r)} V_0. & \end{aligned}$$

When both constraints bind, we have that

$$E(1+r) = \frac{K}{V_0(m + (1-m)(1-\gamma)) - K},$$

assuming that m is sufficiently large to ensure that the denominator in the above expression is positive.

Again, this implies that the sponsor is indifferent between different values of (E, r) such that the above holds, and $r = 0$ is optimal without loss of generality. In this case, the following result characterizes the optimal contract.

Proposition 3. *Suppose $K < V_0(m + (1-m)(1-\gamma))$. When no retail investors are over-confident, the optimal contract with redeemable shares features $r = 0$ and price*

$$P = \frac{1+r}{1 + E(1+r)} V_0, \tag{14}$$

and the sponsor's optimal value is

$$U_S = V_0 - \frac{K}{m + (1-m)(1-\gamma)}.$$

The sponsor strictly prefers selling non-redeemable shares than selling redeemable shares i.e., $U_S^{NR} = V_0 - K > U_S$.

The result highlights that investor over-confidence is a necessary condition for the optimality of redeemable shares and rights in our setting. Recall that redemption rights are not valuable to the sponsor when facing institutional investors who acquire information and redeem shares efficiently. Moreover, when retail investors correctly anticipate that they will not acquire information, the sponsor does not benefit from issuing redeemable shares to them either. As we shall see next, in the presence of overconfident retail investors, the sponsor may strictly prefer to issue redeemable units.

4.2 Optimal contract

We now characterize the optimal contract. First, note that if

$$((1-m)(1-\gamma) + m) < K/W,$$

then there are too many redemptions in equilibrium and the project cannot be financed, even if all investors initially buy units. On the other hand, if

$$(1-m)(1-\gamma) \geq K/W,$$

then only institutional investors need to invest to finance the project, and Proposition 2 implies that non-redeemable shares are optimal. However, when

$$K/W \in ((1-m)(1-\gamma), ((1-m)(1-\gamma)+m)), \tag{15}$$

then we need to ensure that both retail and institutional investors participate in order to finance the project. In this case, there exists a $\bar{\beta}$ such that

$$(1-m)(1-\gamma) + m\left(1 - G\left(\bar{\beta}\right)\right) = K/W, \tag{16}$$

which reflects the fact that, that in equilibrium, all institutional investors and the most overconfident retail investors participate. The marginal retail investor $\bar{\beta}$ is indifferent between acquiring units and not i.e., their participation constraint (8) holds with equality, which implies that

$$P = \frac{1}{\left(1-\bar{\beta}\right)+\bar{\beta}q} \frac{(1+r)V_0 - \bar{\beta}(1-q)V_l}{1+E(1+r)} \equiv P\left(\bar{\beta}\right). \tag{17}$$

Denote the degree of **overpricing** due to overconfidence by $\Pi\left(\bar{\beta}\right)$, where

$$\Pi\left(\bar{\beta}\right) = \frac{P\left(\bar{\beta}\right)}{P(0)} = \frac{\left(1-(1-q)\bar{\beta}\frac{V_l}{(1+r)V_0}\right)}{1-(1-q)\bar{\beta}} \geq 1, \tag{18}$$

and $P(0) = \frac{1+r}{1+E(1+r)}V_0$ denotes the price that obtains when retail investors do not exhibit overconfidence (see Equation (14)). Over-pricing occurs because overconfident retail investors overvalue the option to redeem shares conditional on negative information. Hence, $\Pi\left(\bar{\beta}\right)$ increases in the probability of negative information (i.e., increases in $(1-q)$) and decreases in the relative payoff conditional on this information (i.e., decreases in V_l/V_0). Over-pricing also increases with r, since overconfident investors over-value rights more.

The optimal number of units E sold by the sponsor is characterized by

$$E = \frac{\left((1-m)+m\left(1-G\left(\bar{\beta}\right)\right)\right)}{P}W. \tag{19}$$

This implies that the sponsor must raise more than K to finance the project in date one, since we can combine Equations (16) and (19) to get

$$EP = \frac{(1-m) + m\left(1 - G\left(\bar{\beta}\right)\right)}{(1-m)(1-\gamma) + m\left(1 - G\left(\bar{\beta}\right)\right)} K \equiv \Lambda\left(\bar{\beta}\right) K. \tag{20}$$

Here, $\Lambda\left(\bar{\beta}\right) \geq 1$ denotes a **financing multiplier** that reflects the extent to which date one financing exceeds K to account for future redemptions. Ceterus paribus, $\Lambda\left(\bar{\beta}\right)$ decreases in the mass m of retail investors and their level of overconfidence (e.g., if $G(\beta)$ shifts to the right), but increases in the precision of interim information γ. Together with the condition that informed investors redeem their shares whenever $x = l$ (i.e., Condition (4)), the above conditions characterize the equilibrium.

Proposition 4. *(i) Suppose* $K \in ((1-m)(1-\gamma) W, ((1-m)(1-\gamma) + m) W)$, *and*

$$q(1-\gamma) V_h > K. \tag{21}$$

Then, the optimal contract with redeemable shares (E, r, P) *is characterized by Equations (4), (16)-(19). Specifically, there exists a* $\bar{\beta} \in [0,1]$ *which is characterized by Equation (16), such that all institutional investors and retail investors with* $\beta \geq \bar{\beta}$ *buy units at date one. Informed investors keep their shares when* $x = h$ *and redeem when* $x = l$, *and investors who redeem keep*

$$r = \left(1 - \bar{\beta}\right) \frac{V_h - V_0}{V_0} \tag{22}$$

rights. The equilibrium price is $P\left(\bar{\beta}\right)$, *given by Equation (17), and the sponsor's optimal value is*

$$U_S\left(\bar{\beta}\right) = V_0 - \frac{\Lambda\left(\bar{\beta}\right)}{\Pi\left(\bar{\beta}\right)} K, \tag{23}$$

where the financing multiplier in equilibrium is given by

$$\Lambda\left(\bar{\beta}\right) = 1 + (1-m)\gamma \frac{W}{K},$$

and equilibrium overpricing is given by

$$\Pi\left(\bar{\beta}\right) = \frac{V_h}{V_h - (V_h - V_l)(1-q)\bar{\beta}}. \tag{24}$$

Furthermore, if the mass of retail investors m *is sufficiently large, i.e.,*

$$m > 1 - \frac{\bar{\beta} K (1-q)(V_h - V_l)}{\gamma W \left(V_h - (V_h - V_l)(1-q)\bar{\beta}\right)} \tag{25}$$

then this contract is optimal and dominates selling non-redeemable shares i.e., $U_S\left(\bar{\beta}\right) > U_S^{NR} = V_0 - K$.
(ii) If $\left(\left(1-m\right)\left(1-\gamma\right)+m\right)W < K$, *then the project cannot be financed.*
(iii) If $\left(1-m\right)\left(1-\gamma\right)W \geq K$, *then only institutional investors invest and the optimal contract features non-redeemable shares.*

The result has two parts. First, when the investment cost is not too high or too low, the sponsor offers a contract with redeemable shares and non-zero rights $r > 0$ in equilibrium. As we show in the proof, a sufficient condition for this contract to be feasible is given by Condition (21), which ensures that the optimal number of shares E is well-defined. Intuitively, Condition (21) requires that the project is sufficiently profitable, so that for any marginal investor $\bar{\beta}$, it is possible to issue enough shares to finance the project, taking future redemptions into account.

Second, when there are sufficiently many retail investors, this contract is optimal. In fact, the sponsor strictly prefers it to selling non-redeemable shares. To see why, note that the sponsor faces the following tradeoff from issuing redeemable shares. On the one hand, the sponsor has to raise more financing than K when using redeemable shares - this is captured by the financing multiplier $\Lambda\left(\bar{\beta}\right) > 1$. On the other hand, since overconfident retail investors over-value shares in the firm, as captured by $\Pi\left(\bar{\beta}\right) > 1$, the sponsor needs to issue fewer units and suffers less dilution. The sponsor is better off issuing redeemable shares when the impact of overpricing is larger than than the financing multiplier, i.e., when $\Pi\left(\bar{\beta}\right) > \Lambda\left(\bar{\beta}\right)$. This arises when the mass of retail investors is sufficiently large, which is given by Condition (25).

Rewriting the optimality condition (25) implies that SPACs are optimal whenever

$$\left(1-\bar{\beta}+\bar{\beta}\frac{V_0}{V_h}\right)\left(1+\left(1-m\right)\gamma\frac{W}{K}\right) < 1.$$

The LHS is increasing in $h-l$ and γ. Thus, SPACs are optimal for riskier and less transparent firms. Consistent with this, Bai et al. (2020) document that firms choosing SPACs are riskier and have higher growth, which points to more uncertainty conditional on interim information.

4.3 Features of the optimal contract

Next, we characterize some features of the equilibrium contract with redeemable shares.

Composition of investors. The financing condition (16) characterizes the mix of investors that participate in equilibrium. Intuitively, one can represent the investor demand for risky investments, net of redemptions, as

$$Q(\beta) \equiv W((1-m)(1-\gamma) + m(1-G(\beta))), \tag{26}$$

where β is the type of the marginal investor. In particular, all institutional investors participate and contribute $W(1-m)(1-\gamma)$ to the aggregate demand function, net of redemptions. Similarly, $Q(\beta)$ is decreasing in β, which reflects that only the most overconfident retail investors participate. The financing condition implies that, in equilibrium, the aggregate demand for the risky security $Q(\beta)$ equals the aggregate supply K when the marginal type of retail investor is $\bar{\beta}$ i.e., $Q(\bar{\beta}) = K$.

The above immediately implies that an increase in investor wealth W, or a decrease in required financing K, leads to an increase in $\bar{\beta}$ - the marginal retail investor must be more over-confident for the financing market to clear. Similarly, when the precision of interim information γ increases, the institutional investors demand less, net of redemptions, and the sponsor needs to attract more retail investors. This leads to the marginal retail investor being less overconfident.

The impact of an increase in the fraction m of retail investors is more subtle. To see why, note that $\frac{dQ}{dm} = 0$ implies that

$$mG'(\beta)\frac{\partial\bar{\beta}}{\partial m} = \left(1 - G\left(\bar{\beta}\right)\right) - (1-\gamma).$$

The direct effect is to scale up demand from a fraction $1 - G(\bar{\beta})$ of retail investors, which relaxes the financing constraint and pushes $\bar{\beta}$ upwards. The indirect effect is to scale down demand from institutional investors net of redemptions by $(1-\gamma)$, which tightens the financing constraint (16), pushing $\bar{\beta}$ lower. The overall effect of m on the marginal investor type then depends on which effect dominates: when the precision of interim information is sufficiently high (low), an increase in m increases $\bar{\beta}$ (decreases $\bar{\beta}$, respectively).

Rights. In equilibrium, the sponsor offers strictly positive rights r per unit (see Equation (22)). The sponsor faces the following tradeoff: an increase in r leads to more dilution for the sponsor, but also attracts overconfident retail investors who over-value the optionality that these rights embed. The latter effect implies that the number of rights offered per unit decreases with the level of payoffs (i.e., an increase in V_0 holding $\mu_0$fixed) but increases with a mean preserving spread (i.e., when $h - l$ increases).

Investor Expected Returns. A key empirical regularity about SPACs is the substantial difference in returns earned by institutional investors who redeem their shares and retail investors who do not (see Klausner and Ohlrogge (2020) and Gahng et al. (2021)). Our model naturally gives rise to this prediction since institutional investors efficiently acquire and exploit information to redeem their shares, while retail investors incorrectly overestimate their ability to do so and, consequently, over-pay for their units. Specifically, the per share expected return to retail investors is

$$R_R \equiv \frac{1}{P}\left(\frac{1+\bar{r}}{1+E\left(1+\bar{r}\right)}V_0 - P\right) = -\bar{\beta}\left(1-\frac{V_0}{V_h}\right) < 0, \tag{27}$$

while the return for institutional investors is

$$R_I \;\equiv\; \frac{1}{P}\left(\frac{\left(1+\bar{r}\right)qV_h + \bar{r}\left(1-q\right)V_l}{1+E\left(1+\bar{r}\right)} - Pq\right) = \left(1-\bar{\beta}\right)\left(1-\frac{V_0}{V_h}\right) > 0.$$

Consistent with intuition, the return to retail investors becomes more negative with the overconfidence of the marginal retail investor. Moreover, the return to institutional investors also decreases with $\bar{\beta}$: as the marginal retail investor becomes more overconfident, the risky security is overvalued, but this reduces the expected return for institutional investors. Note that retail investors are worse off for riskier, more positively skewed payoffs. Specifically, R_R become more negative with (i) a mean preserving spread in payoffs, or (ii) when V_0/V_h is low. Intuitively, this is because, all else equal, these projects have higher volatility and more lottery like payoffs, and so are more overvalued by retail investors for their higher option value.

Consistent with our results, Gahng et al. (2021) have documented that in SPACs with more rights (or warrants), buy-and-hold returns are lower. Plugging the optimal price in Equation (17) in to the return in Equation (27) implies that $dR_R/dr < 0$, i.e. returns are indeed lower when the SPAC issues more rights per unit. Moreover, Gahng et al. (2021) found that recently, increased entry by institutional investors has led SPACs to issue fewer rights and warrants per unit and has reduced returns. This is consistent with our model. When $\gamma < G\left(\bar{\beta}\right)$, i.e. information about the target is relatively imprecise, then a higher portion of institutional investors (i.e. a smaller m) reduces $\bar{r}$ (in Equation (22)) and reduces institutional investors return R_I.

5 Sponsor effort and regulatory intervention

Our benchmark analysis highlights that while issuing redeemable shares can make the sponsor (and institutional investors) better off at the expense of overconfident retail investors, it does not affect the expected value of the firm and, consequently, leaves overall welfare unchanged. In particular, relative to a setting in which only non-redeemable shares are issued, the total expected surplus remains the same (i.e., $V_0 - K$). While useful for developing intuition, such a model in not useful for understanding the implications of regulatory policy, since the SPAC structure offers no social benefit.

In this section, we extend the benchmark model, so that redeemable shares can affect the value of the firm, and consequently, total surplus. Specifically, suppose that the sponsor chooses whether or not to exert effort (denoted by $e_S \in \{0,1\}$) at a cost κ to improve the average payoff of the project by $z > 1$. One can interpret this as the sponsor deciding whether to exert effort to find a more profitable target firm. Let (E, r, P) denote the optimal contract with redeemable shares in Proposition 4 and (E_{NR}, P_{NR}) denote the optimal contract without redeemable shares from Proposition 1. If

$$\frac{z}{1 + E\,(1 + r)} \geq \kappa > \frac{z}{1 + E^{NR}}, \tag{29}$$

then the sponsor only exerts costly effort if she can issue redeemable shares, but not if she is restricted to offer only non-redeemable shares. Moreover, if z is sufficiently large, then social surplus is higher when the sponsor can issue redeemable shares.

We explore the implications of regulatory interventions in this setting. We show that mandating transparency may decrease investor welfare, while restricting access by investor sophistication or limiting / eliminating rights and warrants from the issuance can improve outcomes for retail investors.

Mandating greater disclosure. A common concern with SPAC transactions is that disclosure requirements are less stringent than standard IPOs. A natural response might be to propose policies that improve the quality, or precision, of interim information available to investors i.e., increase γ. However, we find that this may be detrimental. An increase in γ leads to a decrease in overconfidence of the marginal investor $\bar{\beta}$ when the financing condition (16) binds. However, an increase in γ also leads to an increase in the equilibrium financing multiplier Λ, an increase in V_h and a decrease in q. Together this implies that the equilibrium return to institutional investors, R_I, increases with γ (see Equation (28)). However, the impact on retail investor returns R_R, overpricing $\Pi\left(\bar{\beta}\right)$, and sponsor surplus U_S are ambiguous.

Specifically, an increase in γ has two offsetting effects on R_R and $\Pi\left(\bar{\beta}\right)$ (see Equations (27) and (24), respectively). On the one hand, an increase in γ increases the payoff V_h conditional on good news, which leads retail investors to overpay for the risky asset more, and so makes their return R_R more negative and overpricing more severe. On the other hand, an increase in γ implies there are more redemptions by institutional investors, which forces the sponsor to cater to less overconfident investors, so that $\bar{\beta}$ decreases. Specifically, implicit differentiation of the demand function $Q\left(\bar{\beta}\right)$ in Equation (26) yields:

$$\frac{\partial\bar{\beta}}{\partial W}=-\frac{(1-m)}{mG'\left(\bar{\beta}\right)}.$$

This implies that when m is sufficiently small or the demand function $Q(\beta)$ is sufficiently insensitive to β (i.e., $G'(\beta)$ is low), overpricing is lower and retail investor returns are less negative as information precision increases. On the other hand, when the mass of retail investors is large and the aggregate demand if very sensitive to β, overpricing is higher and retail investor returns are more negative when interim information quality improves. Hence, transparency may not improve investor welfare, when these investors are overconfident.

Restricting Investor Access. Suppose we restrict investment in SPACs so that only sufficiently sophisticated investors (i.e., $\beta<\beta_{max}$) can participate, e.g., by restricting access to accredited investors. This implies that the financing constraint is given by

$$(1-m)(1-\gamma)+m\left(G(\beta_{max})-G\left(\bar{\beta}\right)\right)\geq K/W.$$

As more naive investors are excluded (i.e., β_{max} decreases), the marginal retail investor type decreases as well (i.e., $\bar{\beta}$ decreases), and the sponsor is forced to cater to a more sophisticated pool of investors. In equilibrium, the above condition binds, and so the overall effect of restricting investor access is to lower $\bar{\beta}$.

Given the increase in investor sophistication, the sponsor responds by reducing the number of rights r offered in equilibrium (see Equation (22)). As a result, the return for institutional investors R_I decreases, while the retail investors' returns increase (i.e., R_R becomes less negative). Also, while the financing multiplier Λ is unaffected, overpricing $\Pi\left(\bar{\beta}\right)$ decreases with β_{max}. This implies the sponsor's surplus decreases with β_{max} since she has to sell more units to finance the project. This implies that one can optimally pick β_{max} to ensure Equation (29) binds with equality in order to maximize social surplus.

Redeemable shares without rights. A recent innovation in SPAC design is to restrict or eliminate warrants and rights as part of initial investment in an effort to limit dilution.[19] We show that this may improve retail investors' return, provided that the sponsor is still willing to exert effort. In our setting, restricting $r=0$ leaves the financing condition unaffected.

[19] See, for example https://www.kirkland.com/news/in-the-news/2020/09/blank-check-sponsors-get-creative.

However, the price is given by

$$P\left(\bar{\beta};r=0\right)=\frac{1}{\left(1-\bar{\beta}\right)+\bar{\beta}q}\frac{V_0-\bar{\beta}\left(1-q\right)V_l}{1+E},$$

and as a result, the informed investor's IC constraint (4) is slack. In particular, this implies that overpricing, which is given by

$$\Pi\left(\bar{\beta};r=0\right)=\frac{P\left(\bar{\beta};r=0\right)}{P\left(0;r=0\right)}=\frac{1-\bar{\beta}\left(1-q\right)\frac{V_l}{V_0}}{1-\bar{\beta}\left(1-q\right)}\geq 0 \tag{30}$$

is lower than $\Pi\left(\bar{\beta}\right)$ when r is unconstrained (see Equation (18)). The sponsor surplus is given by

$$U_S\left(\bar{\beta};r=0\right)=V_0-\frac{\Lambda\left(\bar{\beta}\right)}{\Pi\left(\bar{\beta};r=0\right)}K\leq U_S\left(\bar{\beta}\right),$$

where $U_S\left(\bar{\beta}\right)$ is the sponsor's optimal value in Equation (23). To ensure that the sponsor exerts effort, we require that

$$\frac{z}{1+E}=z\left(1-\frac{\Lambda\left(\bar{\beta}\right)}{\Pi\left(\bar{\beta};r=0\right)}\frac{K}{V_0}\right)>\kappa.$$

Overall, returns for retail investors are given by

$$R_R\left(r=0\right)=\frac{1}{P}\left(\frac{1}{1+E}V_0-P\right)=\left(\frac{1}{\Pi}-1\right)=-\beta\frac{q\left(V_h-V_0\right)}{V_0\left(1-\beta\right)+\beta qV_h}>R_R\left(r\right),$$

where $R_R\left(r\right)=-\beta\left(\frac{V_h-V_0}{V_h}\right)$ is the return when r is unconstrained. This is intuitive - since there are no redemption rights, investors do not overvalue the units as much as in the unconstrained benchmark. Similarly,

$$R_I\left(r=0\right)=\frac{1}{P}\left(\frac{qV_h}{1+E}-Pq\right)=q\left(\frac{V_h}{V_0}\frac{1}{\Pi}-1\right)=\left(1-\bar{\beta}\right)\frac{q\left(V_h-V_0\right)}{V_0\left(1-\beta\right)+\beta qV_h},$$

which implies the return institutional investors is lower than the unconstrained benchmark.

6 Extensions

6.1 Private Investment in Public Equity

A common feature in SPAC transactions is that the sponsor raises part of the financing for the acquisition from large institutional investors using private investment in public equity, or PIPE, transactions. For instance, Klausner and Ohlrogge (2020) show that 25% of the cash raised in a SPAC reverse merger is raised from PIPE investors. A common explanation for PIPE investment is that the investors make up for the cash shortfall from redemptions at the time of the merger. Moreover, since PIPE investors are often large institutional investors, they conduct due diligence on the proposed merger and often acquire proprietary information about the target.

In this section, we extend the benchmark model to allow the sponsor to raise money from a PIPE investor to cover a short-fall if there are redemptions at date two. We show that while PIPE investment benefits the sponsor, it may lead to lower returns for retail investors.

Specifically, we assume that the PIPE investor can observe the project payoff V at this stage and is a large investor, and so has bargaining power. At the time of the merger, the sponsor can raise C dollars in one of two ways: (i) offer a fraction ϕ of her shares to the PIPE investor, or (ii) raise additional, external financing at a cost $L(C)$, which is strictly convex and satisfies $L'(C) \geq 1$. Since the sponsor offers a fraction of her stake, the total number of shares issued $s \equiv 1 + E(1+r)$ remains unchanged. We assume that the PIPE investor and sponsor engage in Nash bargaining with bargaining power $\{\rho, 1-\rho\}$, respectively.

These assumptions closely match institutional practice. As Gahng et al. (2021) demonstrate, SPAC sponsors forfeit about 34% of their shares to induce investors to contribute capital, and these inducements are larger when there are more redemptions.

Since there are no redemptions when $V = h$, the sponsor only approaches the PIPE investor when $V = l$. In this case, the sponsor's payoff to securing PIPE investment is

$$\frac{1-\phi}{s} l,$$

while the payoff to securing alternate financing (which serves as a threat point, or outside option, for bargaining) is

$$\frac{1}{s} l - L(C).$$

Similarly, the PIPE investor's payoff from bargaining is

$$U_P = \frac{\phi}{s} l - C,$$

while their outside option is normalized to zero. The Nash bargaining solution is given by solving the problem

$$\max_{\phi}\left(\phi\frac{l}{s}-C\right)^{\rho}\left(L\left(C\right)-\phi\frac{l}{s}\right)^{1-\rho},$$

which implies that the sponsor offers a fraction

$$\phi=\frac{\left(1-\rho\right)C+\rho L\left(C\right)}{l}\times s$$

of his stake in the firm. Then, the expected payoff to the sponsor from raising C from PIPE investors is given by

$$\begin{aligned}U_S&=\frac{1}{1+E\left(1+r\right)}\left(\mu_0 h+\left(1-\mu_0\right)\left(1-\phi\right)l\right)\\&=\frac{V_0}{1+E\left(1+r\right)}-\left(1-\mu_0\right)\left(\left(1-\rho\right)C+\rho L\left(C\right)\right).\end{aligned}$$

Relative to the benchmark analysis of Section 4, the second term in the above expression captures the loss due to the dilution of the sponsor's stake that results from bargaining with the PIPE investor. However, raising money from the PIPE investor also affects the sponsor's ability to exploit retail investors since it changes the financing constraint. Specifically, if the sponsor raises C from the PIPE investor, then the financing constraint in (16) changes to:

$$\left(\left(1-m\right)\left(1-\gamma\right)+m\left(1-G\left(\bar{\beta}\right)\right)\right)W+C=K. \tag{31}$$

This implies that increasing C relaxes the financing constraint, which leads to an increase in the overconfidence of the marginal retail investor i.e., $\bar{\beta}$. The optimal choice of C trades off the sponsor's benefit from catering to more overconfident retail investors against the cost of higher dilution from the PIPE investor. The optimal choice is characterized by the following proposition.

Proposition 5. *Suppose that $G'\left(\beta\right)$ is strictly increasing. Then, when μ_0 is sufficiently large or m is sufficiently small, the sponsor optimally raises $C>0$ via PIPE investments. The optimal contract (E,r,P) is the one characterized by Proposition 4 where the marginal retail investor $\bar{\beta}$ is determined by Equation (31). The sponsor's optimal value is given by*

$$U_S\left(\bar{\beta}\right)=V_0-\frac{\Lambda\left(\bar{\beta}\right)}{\Pi\left(\bar{\beta}\right)}K-\left(1-\mu_0\right)\left(\left(1-\rho\right)C+\rho L\left(C\right)\right),$$

where the financing multiplier is given by

$$\Lambda\left(\bar{\beta}\right) = 1 + \frac{\gamma\left(1-m\right)W - C}{K},$$

and equilibrium over pricing $\Pi\left(\bar{\beta}\right)$ *is given by Equation* (24)*. Moreover, the optimal level of cash raised is decreasing in the PIPE investor's bargaining power (i.e.,* $dC/d\rho \leq 0$*) and the mass of retail investors (i.e.,* $dC/dm \leq 0$*), but increasing in the initial level of financing required (i.e.,* $dC/dK \geq 0$*) and in the precision of information available to institutional investors (i.e.,* $dC/d\gamma > 0$*).*

Raising capital using PIPE financing (i.e., increasing C) has three effects on the sponsor's payoffs. First, it lowers the financing multiplier $\Lambda\left(\bar{\beta}\right)$ in equilibrium, which increases U_S. Second, because bargaining with the PIPE investor leads to dilution, it decreases the U_S. Finally, it increases the overconfidence of the marginal retail investor, and so increases overpricing $\Pi\left(\bar{\beta}\right)$ and U_S. The condition $G'\left(\beta\right)$ ensures that the threshold $\bar{\beta}$ is concave in C, which ensures that the sponsor's value is concave in C as well. The level of cash raised via PIPE financing decreases as the bargaining power of the the PIPE investor increases. This is intuitive - an increase in the bargaining power of the PIPE investor implies the sponsor has to pay more (via dilution) to raise cash.

The response of the level of PIPE financing to underlying parameters is intuitive. For instance, an increase in the bargaining power of the PIPE investor implies it is costlier (due to higher dilution) for the sponsor to raise PIPE financing. Similarly, an increase in the mass of retail investors implies there are fewer redemptions by (institutional) investors, and so the sponsor needs to rely on PIPE financing less. In contrast, an increase in K or an increase in γ (which leads to more redemptions) implies that the sponsor must raise more capital, all else equal, and so C increases.

A commonly proposed benefit of PIPE investors in SPAC transactions is that they certify the quality of the target. Because PIPE investors are often more sophisticated and better informed than retail investors, their participation in an acquisition serves a "stamp of approval." Our analysis suggests that the impact of PIPE investing on retail investors is more nuanced. Even though PIPE investors are better informed, their presence allows the sponsor to target more optimistic retail investors. As a result, the return to retail investors R_R (in Equation (27)) becomes more negative as C increases.

6.2 Costly information acquisition by retail investors

Assumption 1 in the benchmark model implies that the retail investors never acquire information. In this section, we relax the assumption to study how the optimal contract and equilibrium depend on the attention cost $c_R = c$ for retail investors. The following proposition characterizes the equilibrium.

Proposition 6. *Let*

$$\bar{c} \equiv (1-q) W \frac{V_h - V_l}{V_h},$$

and define

$$c\left(\bar{\beta}\right) \equiv W (1-q) \frac{V_0 - V_l}{V_0 - \bar{\beta}(1-q) V_l},$$

where $\bar{\beta}$ is the marginal investor given the financing constraint (16).

(i) If $c > \bar{c}$, then the optimal contract is characterized by Proposition 4.

(ii) If $c < c\left(\bar{\beta}\right)$, then the sponsor prefers to sell non-redeemable shares.

(iii) If $c \in \left[c\left(\bar{\beta}\right), \bar{c}\right]$ there exists a contract which features redeemable shares with

$$r = \frac{1}{V_0}\left(\frac{(1-q) V_l \left(W - \bar{\beta} c\right)}{W (1-q) - c} - 1\right) > 0, \text{ and } P = \frac{(1-q) V_l}{1 + E(1+r)} \frac{W}{W(1-q) - c}.$$

The sponsor's optimal value is given by $U_S\left(\bar{\beta}\right) = V_0 - \frac{\Lambda\left(\bar{\beta}\right)}{\Pi\left(\bar{\beta}\right)} K$, where the financial multiplier is given by

$$\Lambda\left(\bar{\beta}\right) = 1 + \gamma (1-m) \frac{W}{K},$$

and equilibrium overpricing is given by

$$\Pi\left(\bar{\beta}\right) = \frac{P}{P_0} = \frac{(1-q) V_l}{(1+r) V_0} \frac{W}{W(1-q) - c} = \frac{W}{W - \bar{\beta} c}. \tag{32}$$

Furthermore, if the mass of retail investors is sufficiently large, then this contract is optimal and dominates selling non-redeemable shares i.e., $U_S\left(\bar{\beta}\right) > U_S^{NR} = V_0 - K$.

The result is intuitive. When the cost to retail investors is sufficiently high (i.e., $c > \bar{c}$), then retail investors do not acquire information and so we recover the equilibrium characterized by Proposition 4. On the other hand, when costs are sufficiently low (i.e., $c < c\left(\bar{\beta}\right)$), then all retail investors acquire information and redeem shares for $x = l$ if the sponsor issues redeemable shares. In this case, selling redeemable shares is suboptimal and the sponsor strictly prefers selling non-redeemable shares instead (as in the benchmark with only institutional investors in Section 4.1.2). This observation highlights that in order to be an optimal contract from the sponsor's perspective, the payoffs to the SPAC must be sufficiently opaque i.e., c needs to be high enough.

Finally, for intermediate levels of attention cost, the information constraint $\Delta_R = c$ binds, where Δ_R is defined in Equation (5). In this case, the optimal contract with redeemable shares ensures that retail investors are indifferent between acquiring information and not, and dominates the contract with non-redeemable shares when the mass of retail investors is sufficiently high. While the equilibrium financing multiplier $\Lambda\left(\bar{\beta}\right)$ remains the same as in the benchmark model, equilibrium overpricing is now given by Equation (32), and increases with the retail attention cost c.

Moreover, in this case, we can show that the expected return to retail investors and institutional investors are given by

$$R_R = -\bar{\beta}\frac{c}{W} \text{ and } R_I = \left(1-\bar{\beta}\right)\frac{c}{W},$$

respectively. Consistent with intuition, this implies that when the project is more opaque, i.e., c is larger, retail investors earn lower returns, while institutional investors earn higher returns. As such, policy interventions that increase the transparency about target projects (i.e., lower c) improve retail investor returns and lower institutional investor returns.

6.3 Warrants

In our benchmark model, we assume that the sponsor issues units that consist of redeemable shares and rights, which can be converted to shares at no cost. In practice, SPAC sponsors often use warrants instead, which allow the owner of a unit to acquire additional shares at a fixed, exercise price. The terms for warrant exercise vary significantly across transactions, and sponsors often reserve the right to redeem (or call) their warrants at a time of their choosing. The complexity of these transactions has raised concerns from the SEC and FINRA, especially on behalf of unsophisticated, retail investors who may not completely understand the terms of the warrant, and consequently, exercise them optimally.[20]

In this section, we show that our main results go through when SPACs issue warrants instead of rights. In particular, issuing units which consist of redeemable shares and warrants is optimal. Intuitively, the key mechanic in our model is that retail investors are overconfident and hence overestimate the value of the option to redeem shares. Whether the sponsor issues rights or warrants as part of the units is secondary. With warrants, the sponsor's

[20] For example, see https://www.finra.org/investors/insights/spac-warrants-5-tips, and https://www.sec.gov/oiea/investor-alerts-and-bulletins/what-you-need-know-about-spacs-investor-bulletin.

problem becomes nonlinear, because the number of shares outstanding depends on how many warrants are exercised, which precludes an analytical characterization. Instead, we numerically characterize the optimal contract consisting of redeemable shares and warrants in this subsection.

Specifically, suppose the sponsor sells E units consisting of 1 redeemable shares and w warrants, each of which can be exercised by the investor at an exercise price X. Consistent with stylized facts, we assume that warrants can be exercised after the financing stage for the project.[21] Moreover, we assume that while the sophisticated, institutional investors optimally choose whether or not to exercise their warrants, while unsophisticated, retail investors do not exercise their warrants. Note that if the project's cash-flows are V, the warrant should only be exercised if and only if

$$\frac{1}{1+E\left(1+w\right)}\left(V+wEX\right)>X\Leftrightarrow\frac{V}{1+E}>X.$$

Suppose that $X\in\left(\frac{l}{1+E},\frac{h}{1+E}\right)$ so the warrants are only exercised when $V=h$. Note that if $X>\frac{h}{1+E}$, then the warrants are never exercised, and so irrelevant; on the other hand, if $X<\frac{l}{1+E}$, then the warrants are always exercised and so are analogous to rights we consider in the benchmark analysis.

Since institutional investors exercise their warrants, but retail investors do not, the total number of shares when $V=h$ is $1+E\left(1+\left(1-m\right)w\right)$, while the total number of shares when $x=l$ is $1+E$. Moreover, the terminal payoff reflects the cash added due to the exercise of the warrants i.e., the firm's total payoffs are $h+E\left(1-m\right)wX$ when $V=h$. Moreover, suppose P is such that the institutional investor redeems shares when $x=l$ but keeps them when $x=h$.

This implies the per-unit expected payoff to an institutional investor is given by

$$U^{I}=\begin{array}{c}\mu_0\left(\frac{h+E(1-m)wX}{1+E(1+(1-m)w)}-P\right)+\left(1-\mu_0\right)\left(1-\gamma\right)\left(\frac{l}{1+E}-P\right)\\+\mu_0 w\left(\frac{h+E(1-m)wX}{1+E(1+(1-m)w)}-X\right)\end{array},$$

and a retail investor of type β has expected payoff

$$U^{R}\left(\beta\right)=\beta U_{I}+\left(1-\beta\right)\left(\mu_0\frac{h+E\left(1-m\right)wX}{1+E\left(1+\left(1-m\right)w\right)}+\left(1-\mu_0\right)\frac{l}{1+E}-P\right).$$

[21] Since there is no discounting in our model, it is optimal for investors to wait as long as possible before choosing whether to exercise the warrant. In practice, while warrants are initially issued with long expiration dates, they may be called by the sponsor around the time of the merger (see https://www.spacresearch.com/faq). Assuming that warrants must be exercised at the time of the merger does not substantially change our results.

The financing constraint is the same as in the benchmark model, since warrants are exercised after this stage i.e.,

$$(1-m)(1-\gamma)+m\left(1-G\left(\bar{\beta}\right)\right)=K/W, \tag{33}$$

which pins down the threshold investor $\bar{\beta}$. Moreover, the total number of units sold is given by

$$E=\left(1-m+m\left(1-G\left(\bar{\beta}\right)\right)\right)W/P, \tag{34}$$

which implies

$$\begin{aligned} EP &= \Lambda\left(\bar{\beta}\right)K, \quad \text{where} \\ \Lambda\left(\bar{\beta}\right) &= \frac{1-m+m\left(1-G\left(\bar{\beta}\right)\right)}{(1-m)(1-\gamma)+m\left(1-G\left(\bar{\beta}\right)\right)}, \end{aligned}$$

is the financing multiplier. For a given (w, X), units must be priced so that the marginal retail investor is indifferent, i.e.,

$$U^R\left(\bar{\beta}\right)=0, \tag{35}$$

and so that it is optimal to redeem shares iff $x=l$ i.e.,

$$\frac{\mu_0\left(\frac{h+E(1-m)wX}{1+E(1+(1-m)w)}\right)+(1-\mu_0)(1-\gamma)\left(\frac{l}{1+E}\right)}{\mu_0+(1-\mu_0)(1-\gamma)}>P>\frac{l}{1+E}, \tag{36}$$

and it is optimal to exercise warrants iff $V=h$ i.e.,

$$\frac{h}{1+E}\geq X>\frac{l}{1+W}. \tag{37}$$

The sponsor's problem is to choose (w, X, E, P) to maximize:

$$U_S\equiv\mu_0\frac{h+E(1-m)wX}{1+E(1+(1-m)w)}+(1-\mu_0)\frac{l}{1+E},$$

subject to (33), (34), (35), (36), and (37).Now, outstanding shares depend on how many warrants are exercised, which in turn depends on the realized value V. Because of this, the sponsor's problem cannot be solved analytically in general.

To gain some intuition, consider a constrained version, where we restrict $X=\frac{h}{1+E}$. In this case, the value of the warrant is zero and so the sponsor is indifferent to the number of warrants issued, and the optimal contract with redeemable shares is characterized by the

μ_0	w	X	K	w	X	h	w	X	l	w	X
0.3	1.03	0.03	0.5	0.19	0.42	10	0.7	0.11	0.5	0.74	0.03
0.5	0.7	0.08	1	0.7	0.08	12	0.7	0.08	1	0.7	0.08
0.7	0.35	0.27	1.5	0	0	14	0.72	0.09	1.5	0.68	0.13

W	w	X	γ	w	X	m	w	X
1.5	1.84	0	0.6	0.44	0.16	0.7	0.85	0.06
2	0.7	0.08	0.75	0.7	0.08	0.8	0.7	0.08
2.5	0.43	0.08	0.9	1.12	0	0.9	0.62	0.12

Table 1: Numerical solutions to the sponsor's problem. Baseline parameters are $\mu_0 = 0.5$, $K = 1$, $h = 12$, $l = 1$, $W = 2$, $\gamma = 0.75$, and $m = 0.8$. The distribution $G(\beta)$ is assumed to be uniform.

financing condition (33) and the equilibrium overpricing

$$\Pi\left(\bar{\beta}\right) = \frac{1 - \bar{\beta}\left(1-q\right)\frac{V_l}{V_0}}{1 - \bar{\beta}\left(1-q\right)}.$$

This is identical to the overpricing when we restrict $r = 0$ in the benchmark model (see equation (30)). The benchmark analysis already implies that the sponsor may prefer issuing redeemable units in this case when the fraction of retail investors is sufficiently large.

Now, if we relax the constraint and allow $X < \frac{h}{1+E}$, the value of the warrants is no longer zero. However, unsophisticated investors anticipate exercising the warrants ex-ante but do not exercise them ex-post, they over-value the warrants. When the fraction of retail investors is large, this makes the sponsor better off by increasing equilibrium overpricing. The numerical illustrations in Table 1 confirm this intuition. In this table, we solve the sponsor's problem numerically for various parameter configurations and report the optimal choices of (w, X). Generally, issuing units with redeemable shares is optimal and the sponsor issues $w > 0$ warrants with each unit. Thus, introducing warrants does not substantially change the results of our benchmark model.

7 Conclusions

The recent popularity of SPACs is puzzling, given the complexity of these transactions and the mixed performance across different investor classes. We provide a model in which SPACs arise as an optimal form of financing. The key insight is that a sponsor may find it optimal to issue units with redeemable shares and rights when there are sufficiently many over-confident investors in the market. This because such investors overestimate their own ability to process payoff relevant information and optimally redeem their shares; as a result, they overvalue the optionality embedded in redeemable shares.

Our model matches a number of stylized facts that have already been empirically documented, including positive returns for short-term investors who redeem their shares optimally, negative returns for buy and hold investors, and overall underperformance of SPACs. Moreover, our model provides a number of new predictions relating the target project's characteristics to the composition and sophistication of investors, the equilibrium number of rights per unit, and investor returns. For instance, our model predicts that smaller SPAC transactions (i.e., with lower levels of required financing K) should be associated with more overconfident retail investors (i.e., higher $\bar{\beta}$), higher overpricing and lower returns for buy and hold investors. Similarly, SPAC transactions with more risky targets are associated with more rights / warrants per unit and more negative buy and hold returns.

Finally, we are able to characterize the impact of potential policy interventions. We show that while increases in transparency (decreasing costs of information processing) and restricting access to sophisticated investors tends to improve outcomes for unsophisticated retail investors, mandating disclosure of more information can be counterproductive. Similarly, while PIPE financing in a SPAC transaction is often interpreted as being favorable to retail investors, we show that this can actually leave such investors worse off. Our analysis highlights the importance of understanding the underlying structure of such transactions when evaluating regulatory changes.

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A Proofs

A.1 Proof of Proposition 2

Consider a contract in which investors only redeem shares when $x = l$, i.e. Condition (4) holds. Then, the financing constraint is given by

$$(1-\gamma)\, P \int_i e_i di = (1-\gamma)\, W \geq K.$$

In the following, we assume that this constraint is satisfied, i.e. $W \geq K/(1-\gamma)$. We have $EP = W$ and thus

$$EP = \frac{K}{1-\gamma},$$

which together with $P = V_h/(1+E)$ implies that the sponsor's value satisfies Equation (12).

Now, consider a contract in which investors always keep their shares. This contract must satisfy the IC constraint

$$\frac{V_l}{1+E\,(1+r)} \geq P,$$

otherwise it is optimal to redeem conditional on $x = l$. Since investors never redeem their shares, their participation constraint is given by

$$\frac{(1+r)\, V_0}{1+E\,(1+r)} \geq P.$$

At the optimal contract, the IC constraint above binds and the IR constraint is slack. Since investors never redeem, the financing constraint is given by[22]

$$EP = W \geq K$$

and we have

$$\frac{E}{1+E\,(1+r)} V_l = K,$$

which implies that

$$1+E\,(1+r) = \frac{V_l}{V_l-(1+r)\, K},$$

i.e. the dilution for the sponsor is increasing in r and setting $r = 0$ is optimal. Then, the sponsor's value is given by Equation (13).

[22]Whenever the constraint is slack, we can allocate shares randomly among investors to raise exactly K, since all investors are willing to participate. Since all investors keep their shares, the sponsor's value does not depend on the method of allocation.

Finally, that the optimal contract induces investors to redeem when $x = l$ whenever $(1-\gamma) V_h \geq V_l$ follows by comparing the sponsor values in Equations (12) and (13).

A.2 Proof of Proposition 4

We first show that the constraint set in Proposition 4 is nonempty whenever Condition (15) holds. Plugging in the price in Equation (17), which ensures that type $\bar{\beta}$'s IR condition (8) holds, into the IC constraint (4) yields

$$\frac{V_h}{1+E(1+r)} \geq \frac{1}{\left(1-\bar{\beta}\right)+\bar{\beta}q} \frac{(1+r) V_0 - \bar{\beta}(1-q) V_l}{1+E(1+r)},$$

which is equivalent to

$$V_h \left(\left(1-\bar{\beta}\right)+\bar{\beta}q\right) \geq (1+r) V_0 - \bar{\beta}(1-q) V_l$$

or

$$\bar{\beta} V_0 + \left(1-\bar{\beta}\right) V_h \geq (1+r) V_0,$$

which clearly holds at $r = 0$ for any $\bar{\beta} \in [0,1]$. Since institutional investors always acquire information, their value is larger than any retail investor's for any (E, r, P). Thus, the institutional investors' IR constraint (6) always holds. Finally, combining Equation (19) and the financing condition (16) yields

$$EP = \frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)(1-\gamma)} K$$

and we can plug in the price P from Equation (17) and $r = 0$ to solve for E, which yields

$$1+E = \frac{V_0 - \bar{\beta}(1-q) V_l}{V_0 - \bar{\beta}(1-q) V_l - \left(1-\bar{\beta}+\bar{\beta}q\right) \frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)(1-\gamma)} K}.$$

For E to be well defined, we need that $E \geq 0$, which holds whenever the numerator in the above expression is positive. Since the term

$$\frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)(1-\gamma)} K$$

is strictly increasing in $\bar{\beta}$, a sufficient condition is given by

$$V_0 - (1-q)\,V_l > \frac{K}{1-\gamma},$$

which is equivalent to Condition (21). Thus, there exists a (E, r, P) satisfying all constraints.

We now consider optimality. The IR constraint of type $\bar{\beta}$ must bind at any optimal contract and thus P is given by Equation (17). Combining Equation (19) and the financing condition (16) yields

$$EP = \frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)\,(1-\gamma)}K$$

and plugging in P yields, after some algebra,

$$1+E\,(1+r) = \frac{(1+r)\,V_0 - \bar{\beta}\,(1-q)\,V_l}{(1+r)\,V_0 - \bar{\beta}\,(1-q)\,V_l - (1+r)\left(1-\bar{\beta}+\bar{\beta}q\right)\frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)(1-\gamma)}K}$$

Condition (21) implies that the denominator is positive for any $r > 0$ and $\bar{\beta} \in [0,1]$. Then, $1+E\,(1+r)$ is strictly decreasing in r, which follows by differentiating the above expression, i.e. the sponsor sets r as high as possible.

Plugging P in Equation (17) into the IC constraint (4) implies that incentive compatibility holds whenever

$$V_h\left(1-\bar{\beta}+\bar{\beta}q\right) \geq (1+r)\,V_0 - \bar{\beta}\,(1-q)\,V_l,$$

or equivalently

$$r \leq \left(1-\bar{\beta}\right)\frac{V_h - V_0}{V_0} \equiv \bar{r}.$$

Thus, the sponsor optimally increases r until the IC constraint (4) binds and $r = \bar{r}$ and the optimal (E, r, P) is determined by Conditions (4) and (16)-(19) binding.

When the IC constraint (4) binds, we have

$$1+E\,(1+r) = \frac{V_h}{V_h - (1+r)\frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)(1-\gamma)}K}$$

so that the sponsor's value is given by

$$U_S = \left(V_h - (1+r)\frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+(1-m)\,(1-\gamma)}K\right)\frac{V_0}{V_h}.$$

Then, plugging in $r = \bar{r}$ yields

$$U_S = V_0 - \frac{\left(1-\bar{\beta}\right)V_h + \bar{\beta}V_0}{V_h} \frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+\left(1-m\right)\left(1-\gamma\right)}K. \tag{38}$$

To establish that (E, r, P) characterized in the proposition statement is indeed optimal, we compare the sponsor's value to her value in the following cases: (1) issuing non-redeemable shares; (2) issuing redeemable shares such that investors keep their shares conditional on $x = l$; (3) financing the project only if $V = h$. This exhausts all possible cases.

Non-redeemable shares. We have $U_S > U_S^{NR}$ whenever

$$V_h \geq \left(\left(1-\bar{\beta}\right)V_h + \bar{\beta}V_0\right) \frac{m\left(1-G\left(\bar{\beta}\right)\right)+1-m}{m\left(1-G\left(\bar{\beta}\right)\right)+\left(1-m\right)\left(1-\gamma\right)}, \tag{39}$$

which follows from Equation (38). At $\bar{\beta} = 0$, this condition cannot hold, since

$$\frac{1}{m+\left(1-m\right)\left(1-\gamma\right)} > 1.$$

At $\bar{\beta} = 1$, the condition holds whenever

$$V_h \geq \frac{V_0}{1-\gamma},$$

which is true. Thus, the optimal contract in Proposition (4) dominates selling non-redeemable shares whenever $\bar{\beta}$ is sufficiently close to 1. Given condition (4), this holds whenever the mass of unsophisticated investors is sufficiently large, i.e. there exists a $\hat{\beta}$ close to 1 and and M close to 0 such that $1 - G(\hat{\beta}) = M$.

Investors never redeem. Replace the IC constraint (4) with

$$\frac{1}{1+E\left(1+r\right)}V_l \geq P, \tag{40}$$

which implies that investors keep their shares if they observe $x = l$. In other words, investors never redeem their shares when Condition (40) holds. Since the signal x now does not affect investors decisions, no retail investor acquires information, i.e. $a_i = 0$ for all i. Institutional investors acquire information, since that information is free, but the information does not affect their value. Overall, retail investors and institutional investors now have the identical value

$$U\left(e_i; c_I\right) = U\left(e_i; c_R\right) = e_i\left(\frac{1+r}{1+E\left(1+r\right)}V_0 - P\right).$$

Since $V_l < V_0$, setting

$$P = \frac{1}{1+E\left(1+r\right)}V_l,$$

so that constraint (40) binds is optimal, which leaves the IR conditions (6) and (8) slack. The financing constraint (2) becomes

$$EP = W \geq K,$$

which is slack given Condition (2).[23] Then, the sponsor's value is given by

$$U_S = \frac{V_l - \left(1+r\right)K}{V_l}V_0$$

and setting $r = 0$ is optimal, so that the sponsor's optimal value is

$$U_S^{Keep} = V_0 - \frac{V_l}{V_0}K.$$

Clearly, we have $U_S^{Keep} < U_S^{NR}$, where U_S^{NR} is given by Equation (11). Thus, the optimal contract in which investors always keep their shares is dominated by selling non-redeemable shares. Under the conditions of Proposition 4, we have $U_S > U_S^{NR} > U_S^{Keep}$.

Project financed only when $V = h$. Now, the project is not financed when $V = l$. To avoid complications, assume that all investors receive their contributed funds back when the project is not financed.[24] Then, since the project is financed only if $V = h$, the IC condition

$$\frac{h}{1+E\left(1+r\right)} \geq P \tag{41}$$

must hold, i.e. investors do not redeem their shares conditional on $V = h$. If that condition does not hold, clearly the project is never financed. Now, each investor's value from buying units is

$$\mu_0\left(\frac{1+r}{1+E\left(1+r\right)}h - P\right). \tag{42}$$

[23]Whenever the constraint is slack, we can allocate shares randomly among investors to raise exactly K, since all investors are willing to participate. Since all investors keep their shares, the sponsor's value does not depend on the method of allocation.

[24]This fits the empirical structure of SPACs well, since investors' cash is held in an escrow account until the merger is completed, see e.g. Klausner and Ohlrogge (2020).

In particular, the signal x does not affect investors values, since the project is only financed when $V = h$ and since investors receive their money back when $V = l$. Thus, retail investors never acquire information, since that information provides no value to them and both retail and institutional investors per-share value is given by Equation (42). Institutional investors follow their signal without loss of generality. Whenever

$$\mu_0 \left(\frac{1+r}{1+E(1+r)} h - P \right) \geq 0,$$

all investors participate. Thus, the financing constraint (2) becomes simply

$$EP = W \geq K, \tag{43}$$

which is generally slack.[25] At the optimal price P, the IC constraint (41) binds, which together with the financing constraint (43) implies that

$$1 + E(1+r) = \frac{h}{h - (1+r) K},$$

which is increasing in r. Thus, $r = 0$ is optimal and the sponsor's value is given by

$$U_S^h = \mu_0 (h - K),$$

since the project is only financed when $V = h$. We have $U_S > U_S^h$ whenever

$$(1-\mu_0) l + K \left(1 - \frac{\left(1-\bar{\beta}\right) V_h + \bar{\beta} V_0}{V_h} \frac{m\left(1 - G\left(\bar{\beta}\right)\right) + 1 - m}{m\left(1 - G\left(\bar{\beta}\right)\right) + (1-m)(1-\gamma)} \right) > 0.$$

Thus, a sufficient condition is

$$V_h > \left(\left(1-\bar{\beta}\right) V_h + \bar{\beta} V_0\right) \frac{m\left(1 - G\left(\bar{\beta}\right)\right) + 1 - m}{m\left(1 - G\left(\bar{\beta}\right)\right) + (1-m)(1-\gamma)}.$$

But this is just Condition (39), which we have already established.

A.3 Proof of Proposition 5

In the financing constraint (31), $C = 0$ corresponds to the baseline model (see Equation (16)). The case $C = \gamma(1-m) W$ corresponds to the sponsor raising just enough cash to

[25] As in the previous case, we can randomly allocate shares between investors to raise exactly K.

cover redemptions, while $C = \bar{C} \equiv K - (1-m)(1-\gamma) W$ implies that the sponsor raises no cash from retail investors, i.e. $\bar{\beta} = 1$. Since setting $C > \bar{C}$ results in excess cash, we have $C \in [0, \bar{C}]$ without loss of generality.

For any $C \in [0, \bar{C}]$, the optimal contract is determined by Proposition (4). This follows from a similar argument as in the proof of Proposition (4), which we omit.[26] Plugging this optimal contract into the sponsor's value yields

$$U_S = \left(1 - \frac{\left(1-\bar{\beta}\right) V_h + \bar{\beta} V_0}{V_h} \left(K - C + \gamma (1-m) W\right)\right) V_0 - (1-\mu_0)\left(\rho L(C) + (1-\rho) C\right).$$

The sponsor's problem thus consists of choosing $C \in [0, \bar{C}]$ to maximize this value. Implicitly, the marginal investor $\bar{\beta}$ depends on C via the financing constraint (31), and and the implicit function theorem yields

$$\frac{d\bar{\beta}}{dC} = \frac{1}{mWg\left(\bar{\beta}\right)}.$$

Whenever $G'\left(\bar{\beta}\right)$ is increasing, $\bar{\beta}$ is a concave function of C, and since $L(C)$ is convex, the sponsor's objective is concave as well. Thus, the optimal value of C is determined by the first-order condition

$$\left(\frac{\left(1-\bar{\beta}\right) V_h + \bar{\beta} V_0}{V_h} + \frac{d\bar{\beta}}{dC} \frac{V_h - V_0}{V_h} \left(K - C + \gamma (1-m) W\right)\right) V_0 = (1-\mu_0)\left(\rho L'(C) + (1-\rho)\right).$$

Whenever μ_0 is sufficiently large or m is sufficiently small, we have $dU_S/dC > 0$ at $C = 0$, and thus $C > 0$ is optimal.

The comparative statics in the proposition statement follow by super-or submodularity, i.e. $d^2U_S/dCdK > 0$, $d^2U_S/dCd\gamma > 0$, and $d^2U_S/dCdm < 0$.

A.4 Proof of Proposition 6

Consider the equilibrium with redeemable shares (in Proposition 4). Plugging the optimal contract into Equation (5) implies that retail investors do not acquire information whenever $c \geq \bar{c}$, which follows after some algebra.

Consider now the case $c < \bar{c}$. Then, the contract in Proposition 4 is not feasible. Retail investors acquire information and redeem their shares whenever $x = l$, so that the financing constraint becomes

$$\left(1 - m + m\left(1 - G\left(\bar{\beta}\right)\right)\right)(1-\gamma) \geq K/W,$$

[26] Essentially, all derivations are the same, except that Equation (16) is replaced with Equation (31). Comparing these two equations, the case $C > 0$ is isomorphic to the baseline model with $\hat{K} = K - C$.

i.e. both retail and institutional investors redeem when $x = l$, instead of Equation (16).

We now characterize the optimal contract in this case. Since retail investors anticipate that they will redeem shares, their value is given by

$$\frac{W}{P}\left(\frac{(1+r)\,qV_h + r\,(1-q)\,V_l}{1+E\,(1+r)} - qP\right) - (1-\beta)\,c,$$

which follows from Equation (7). The value of institutional investors is given by Equation (6).

As in the baseline model, the value of a retail investor is increasing in β. Thus, whenever $K/W \in ((1-\gamma)(1-m), 1-\gamma)$, there exists a $\bar{\beta}$ such that the financing constraint binds. The optimal contract renders type $\bar{\beta}$ indifferent, which implies that

$$P = W\frac{(1+r)\,V_0 - (1-q)\,V_l}{(1+E\,(1+r))\left(Wq + \left(1-\bar{\beta}\right)c\right)}.$$

Then, the financing condition yields

$$EP = \left(1 - m + m\left(1 - G\left(\bar{\beta}\right)\right)\right)W = \frac{K}{1-\gamma}$$

so that

$$1 + E\,(1+r) = \frac{(1-\gamma)\left((1+r)\,V_0 - (1-q)\,V_l\right)}{(1-\gamma)\left((1+r)\,V_0 - (1-q)\,V_l\right) - K\,(1+r)\,\frac{Wq + \left(1-\bar{\beta}\right)c}{W}},$$

which is decreasing in r. Thus, the sponsor value increases in r. The IC constraint (4) is now given by

$$V_h \geq \frac{W}{Wq + \left(1-\bar{\beta}\right)c}\left((1+r)\,V_0 - (1-q)\,V_l\right).$$

Since the RHS is increasing in r, this constraint tightens when r is higher. Acquiring information is indeed optimal (Equation (5)) whenever

$$(1-q)\,\frac{W\left((1+r)\,V_0 - (1-q)\,V_l\right) - V_l\left(Wq + \left(1-\bar{\beta}\right)c\right)}{(1+r)\,V_0 - (1-q)\,V_l} \geq c. \tag{44}$$

The LHS is increasing in r, which implies that the constraint slackens when r is higher. Thus, in the optimal contract, the sponsor sets r so that the IC constraint (4) binds, i.e.

$$r = \frac{1}{V_0}\left(\frac{Wq + \left(1-\bar{\beta}\right)c}{W}V_h + (1-q)\,V_l - V_0\right).$$

The condition $c < \bar{c}$ implies that given the optimal r, retail investors indeed acquire information, i.e. Condition (44) holds.

Overall, the sponsor's value is now given by

$$U_S = V_0 - \frac{K}{1-\gamma}\left(\frac{V_0}{V_h} + \frac{\left(1-\bar{\beta}\right)c}{V_h}\right)$$

and

$$U_S < V_0 - \frac{K}{1-\gamma}\frac{V_0}{V_h} < U_S^{NR}.$$

Here, the last inequality follows from the fact that $V_0/((1-\gamma)\,V_h) > 1$. Thus, any contract in which retail investors acquire information is suboptimal and the sender prefers to sell non-redeemable shares instead.

Next, consider a contract in which $c < \bar{c}$, such that investors do not acquire information. Given financing constraint (16) and marginal investor $\bar{\beta}$ (where $\bar{\beta}$ is determined by the financing constraint (16)), the price is again determined by Equation (17). Then, retail investors indeed do not acquire information whenever

$$W\,(1-q)\,\frac{(1+r)\,V_0 - V_l}{(1+r)\,V_0 - \bar{\beta}\,(1-q)\,V_l} \le c, \tag{45}$$

which follows from plugging the optimal price into Equation (5). The LHS is strictly increasing in r and holds at $r = 0$ whenever

$$c \ge c\left(\bar{\beta}\right) \equiv W\,(1-q)\,\frac{V_0 - V_l}{V_0 - \bar{\beta}\,(1-q)\,V_l}.$$

If $c < c\left(\bar{\beta}\right)$ then retail investors always acquire information when the sponsor offers redeemable shares, i.e. Condition (45) does not hold for any $r \ge 0$. As in the previous case, selling redeemable shares is then suboptimal.

In the following, suppose that $c\left(\bar{\beta}\right) \le c < \bar{c}$. Then, the two IC constraints (4) and (45) both tighten as r increases. Whenever $c < \bar{c}$, condition (45) binds, and the IC constraint (4) is slack. Thus, r is given by[27]

$$r = \frac{1}{V_0}\left(\frac{(1-q)\,V_l\left(W - \bar{\beta}c\right)}{W\,(1-q) - c} - 1\right)$$

[27]Here, note that $c < \bar{c}$ implies that $c < W\,(1-q)$ and in particular that $c < W$, which implies that $W > \bar{\beta}c$. That $r \ge 0$ follows from the assumption $c \ge c\left(\bar{\beta}\right)$.

so that

$$P=\frac{(1-q)\,V_l}{1+E\,(1+r)}\frac{W}{W\,(1-q)-c}.$$

Then, using the financing constraint (16), we get

$$1+E\,(1+r)=\frac{1}{1-\frac{W-\bar{\beta}c}{WV_0}\left(K+\gamma\,(1-m)\,W\right)}$$

and the sponsor's value is

$$U_S=V_0-\frac{W-\bar{\beta}c}{W}\left(K+\gamma\,(1-m)\,W\right).$$

Whenever m is sufficiently large, we have $U_S>U_S^{NR}$.

B Additional Analysis

B.1 Additional regulatory interventions

This subsection considers additional regulatory interventions in our benchmark model.

Mandatory Redemption Rights. An alternate regulatory proposal is to require that each unit has at least $\bar{r}$ redemption rights. When this minimum threshold is below the optimal number of rights r issued in equilibrium in Equation (22), the mandate has no effect. Instead, suppose the mandatory minimum exceeds the optimal choice i.e., $\bar{r}>r$.

Note that in this case the financing condition in Equation (16) no longer pins down the marginal investor type. To see why, suppose the marginal investor $\bar{\beta}$ is determined by Equation (16) and that the price P is set so that the IR constraint (8) of type $\bar{\beta}$ binds given $r=\bar{r}$, i.e.

$$P=\frac{1}{\left(1-\bar{\beta}\right)+\bar{\beta}q}\frac{(1+\bar{r})\,V_0-\bar{\beta}\,(1-q)\,V_l}{1+E\,(1+\bar{r})}.$$

Then, the IC constraint (4) cannot hold, since $\bar{r}>r$ implies that

$$P>\frac{V_h}{1+E\,(1+\bar{r})}$$

for any number of shares E.

Instead, suppose that the IC constraint (4) binds so that

$$P=\frac{V_h}{1+E\,(1+\bar{r})}. \tag{46}$$

Then, the marginal retail investor type is determined by the IR constraint (8) which yields

$$\frac{(1+\bar{r})\,V_0 - V_h + \beta\,(1-q)\,(V_h - V_l)}{1 + E\,(1+\bar{r})} \geq 0 \tag{47}$$

for all retail investors who participate. Since the above expression is increasing in β, there exists a threshold type $\tilde{\beta}$ such that all types $\beta > \tilde{\beta}$ participate. Moreover, we can verify that $\tilde{\beta} < \bar{\beta}$. Intuitively, when the minimum number of rights increases, more retail investors participate in equilibrium, and consequently, the marginal type is less overconfident.

Since the financing condition in (16) is slack, the sponsor randomly rations shares to raise exactly $\Lambda\left(\tilde{\beta}\right)K$, so the project is financed. In equilibrium, this implies

$$E = \frac{\Lambda\left(\tilde{\beta}\right)K}{P} = \frac{K\Lambda\left(\tilde{\beta}\right)}{V_h - K\Lambda\left(\tilde{\beta}\right)(1+\bar{r})}. \tag{48}$$

Overall, the equilibrium is now determined by Equations (46), (47), and (48). The sponsor's payoff can be expressed as

$$U_S = V_0 - \frac{\Lambda\left(\tilde{\beta}\right)}{\tilde{\Pi}}K,$$

where overpricing is given by

$$\tilde{\Pi} = \frac{P}{P\,(0)} = \frac{V_h}{(1+\bar{r})\,V_0}.$$

Importantly, overpricing *decreases* with the mandatory threshold $\bar{r}$ (since the marginal investor becomes less overconfident), and this implies sponsor surplus decreases with $\bar{r}$. As before, to ensure that the sponsor exerts effort, we require that

$$z\left(1 - \frac{\Lambda\left(\tilde{\beta}\right)}{\tilde{\Pi}\left(\tilde{\beta}\right)}\frac{K}{V_0}\right) > \kappa,$$

which implies $\bar{r}$ is not too large. Finally, note that returns for retail and institutional investors are given by

$$\tilde{R}_R = \frac{(1+\bar{r})\,V_0 - V_h}{V_h}, \quad \text{and} \quad \tilde{R}_I = \bar{r}\frac{V_0}{V_h},$$

which implies both groups of investors earn higher returns as $\bar{r}$ increases.

Restricting investment stakes. Now consider a policy that restricts the stake of any investor to be at most $\bar{W} < W$. As long as $K \in \left((1-m)\,(1-\gamma)\,\bar{W}, ((1-m)\,(1-\gamma)+m)\,\bar{W}\right)$, the project can be financed using redeemable shares. The financing condition is now given by

$$(1-m)(1-\gamma)+m\left(1-G\left(\bar{\beta}\right)\right)\geq K/\bar{W},$$

which binds in equilibrium. A decrease in $\bar{W}$ leads to a decrease in $\bar{\beta}$ - limiting investor stakes implies the sponsor has to cater to more sophisticated investors on average - and so affects both the financing multiplier and equilibrium overpricing. In particular, overpricing $\Pi\left(\bar{\beta}\right)$ decreases as $\bar{W}$ decreases - since retail investors are forced to invest less, they cannot bid up the shares as much. In turn, this implies that returns for institutions decrease while retail investors earn less negative returns. However, a decrease in $\bar{W}$ also lowers the financing multiplier, since institutional investors are forced to invest less and financing is less sensitive to redemptions.

The overall effect on sponsor surplus depends on the relative magnitude of these effects, and how sensitive the marginal investor's type is to changes in $\bar{W}$. Recall that

$$\frac{d\Lambda}{d\bar{W}}=\frac{(1-m)\,\gamma}{K},\quad \frac{d\Pi}{d\bar{W}}=\frac{\partial\Pi}{\partial\bar{\beta}}\times\frac{\partial\bar{\beta}}{\partial\bar{W}},$$

where

$$\frac{\partial\bar{\beta}}{\partial W}=\frac{(1-m)(1-\gamma)+m\left(1-G\left(\bar{\beta}\right)\right)}{WmG'\left(\bar{\beta}\right)}.$$

These expressions suggest that when (i) m is sufficiently large, or (ii) the demand function $Q(\beta)$ in Equation (26) is sufficiently flat in β (i.e., $G'\left(\bar{\beta}\right)$ is sufficiently low), the over-pricing effect dominates and restricting investment stakes leads to a lower surplus for the sponsor.

B.2 Redemption Mechanics

In our benchmark model, we assume that redeemed shares are given to a third party so that redemptions do not affect the number of shares outstanding. In this appendix, we relax this assumption and characterize how are results are affected when redemptions reduce the number of outstanding shares. While an analytical treatment is not tractable, we can show numerically that issuing redeemable shares is still optimal for the sponsor in this case.

Mechanically, if $R>0$ shares are redeemed, shares outstanding are given by $1+E(1+r)-R$ and each investor's realized per-share value is $V/(1+E(1+r)-R)$. Thus, investors who redeem increase the per-share value of those who do not redeem by reducing dilution. Consider the equilibrium of Section 4.2, i.e. investors redeem their shares when $x=l$ and keep them when $x=h$. How many shares outstanding remain depend on the realized value V. If $V=h$, then no investors redeem, and shares outstanding are simply $s_h=1+E(1+r)$. When $V=l$, all investors who get a signal $x=l$ redeem, so that total redemptions are given by $\gamma(1-m)e_i$, where $e_i = W/P$, and shares outstanding are given by $s_l = 1 + E(1+r) - \gamma(1-m)W/P$. Using Equation (19), we can simplify this expression to

$$s_l = 1 + E\left(\frac{1}{\Lambda(\bar{\beta})} + r\right).$$

Each institutional investor's per-share value is now given by

$$\mu_0\left(\frac{(1+r)h}{s_h} - P\right) + (1-\mu_0)\left(\gamma\left(\frac{(1+r)l}{s_l} - P\right) + (1-\gamma)\frac{rl}{s_l}\right),$$

while the value of retail investor with type β is

$$\beta\left(\mu_0\left(\frac{(1+r)h}{s_h} - P\right) + (1-\mu_0)\left(\gamma\left(\frac{(1+r)l}{s_l} - P\right) + (1-\gamma)\frac{rl}{s_l}\right)\right)$$
$$+ (1-\beta)\left(\mu_0\frac{(1+r)h}{s_h} + (1-\mu_0)\frac{(1+r)l}{s_l} - P\right).$$

As in the baseline model, this value is increasing in β, so that all retail investors with $\beta \geq \bar{\beta}$ participate, and $\bar{\beta}$ is again determined by the financing condition (16). The sponsor optimally sets the price P so that the type-$\bar{\beta}$ investor is indifferent, which now yields

$$P = \frac{1}{1-\bar{\beta}+\bar{\beta}q}\left(\mu_0\frac{(1+r)h}{s_h} + (1-\mu_0)\frac{(1+r)l}{s_l} - \bar{\beta}(1-\mu_0)(1-\gamma)\frac{l}{s_l}\right).$$

Using Equation (20), we can reduce the financing conditions and type $\bar{\beta}$'s participation constraint to

$$\frac{E}{1-\bar{\beta}+\bar{\beta}q}\left(\mu_0\frac{(1+r)h}{1+E(1+r)} + (1-\mu_0)l\frac{1+r-\bar{\beta}(1-\gamma)}{1+\frac{E}{\Lambda(\bar{\beta})}+Er}\right) \quad = \quad \Lambda(\bar{\beta})K.$$

In equilibrium, it must be optimal for investors to redeem shares when $x = l$ and keep them when $x = h$. The analog of the IC constraint (4) is now

$$\frac{\mu_0}{q}\frac{h}{s_h} + \left(1 - \frac{\mu_0}{q}\right)\frac{l}{s_l} \geq P. \tag{50}$$

Thus, the sponsor's problem becomes

$$\max_{(E,r)} \mu_0\frac{h}{s_h} + (1-\mu_0)\frac{l}{s_l}$$

subject to Equations (49) and (50). Equation (49) is non-monotone in E, which implies

μ_0	r	K	r	h	r	l	r	W	r	γ	r	m	r
0.3	0.43	0.5	0.09	10	0.25	0.5	0.3	1.5	0.38	0.6	0.18	0.7	0.28
0.5	0.26	1	0.26	12	0.26	1	0.26	2	0.26	0.75	0.26	0.8	0.26
0.7	0.13	1.5	0.43	14	0.27	1.5	0.23	2.5	0.19	0.9	0.38	0.9	0.24

Table 2: Numerical solutions to the sponsor's problem. Baseline parameters are $\mu_0 = 0.5$, $K = 1$, $h = 12$, $l = 1$, $W = 2$, $\gamma = 0.75$, and $m = 0.8$.

that the sponsor's problem cannot be characterized via first-order conditions. In the proof of Proposition 4, we used the analog of Equation (49) to solve for E as a function of r. Now, this approach yields a quadratic equation for E, which is difficult to characterize analytically. However, the sponsor's problem can be solved numerically. Table 2 reports our numerical solutions for different parameter values. Generally, the optimal contract features $r > 0$, just as in the baseline model.