Consumers as Financiers: 
Consumer Surplus, Crowdfunding, and Initial Coin Offerings

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Abstract

Limited market power prevents an entrepreneur from extracting full surplus from consumers. Hence, traditional intermediaries fail to fund all efficient projects, even absent other frictions. Direct funding by consumers, i.e. crowdfunding, mitigates this underinvestment problem by allowing consumers to commit to pay for their surplus. While a resale market for consumers’ claims helps fund long-term projects, underinvestment persists because future consumers cannot commit. Speculative premia in the resale market can restore efficiency, but also can cause overinvestment. We provide testable implications for crowdfunding with an active resale market, as in the case of initial coin offerings.

Keywords: consumer surplus, market power, efficiency, crowdfunding, initial coin offerings, speculative premium. JEL: G0
Crowdfunding is a way for firms to raise money from a large number of small investors. A multibillion-dollar global crowdfunding industry has emerged as an alternative to traditional funding schemes such as bank loans or venture capital (WorldBank (2013)). In 2012, the United States passed the Jump-start Our Business Startups (JOBS) act to simplify the legal requirements for small business crowdfunding. More recently, a new type of crowdfunding has emerged in the form of initial coin offerings (ICOs) and the more recent security token offerings (STOs). The innovation of ICOs over extant crowdfunding is that digital assets (“cryptocurrencies”) facilitate a liquid resale market.\(^1\) In this paper, we study the efficiency of crowdfunding with and without a resale market: How does crowdfunding differ from traditional intermediary funding?

We start from the observation that once investment is sunk, an entrepreneur may not be able to extract full surplus. The market power that he exercises in the product market determines how surplus is split between the firm and consumers. A firm with no market power extracts none of the surplus, while a perfectly discriminating monopolist extracts all. These differences in market power affect the efficiency of funding by traditional intermediaries (e.g., bank, venture capital, etc.), whose funding predicates on cash flow potential.

If an entrepreneur has limited market power, an efficient project with positive net surplus over production costs may generate negative net cash flow to the entrepreneur. Funding by traditional intermediaries therefore leads to inefficient underinvestment even absent other frictions. Direct funding by consumers, i.e. crowdfunding, mitigates this problem by allowing consumers to commit to pay for their surplus. Building on this insight, we explore the implications of a resale market for consumers’ claims. When consumers have short time horizons, an active resale market helps fund long-term projects. Yet underinvestment persists, since future consumers cannot commit to pay for their surplus. Speculative premium can restore efficiency, but also can cause overinvestment.

To make our argument precise, we present a simple discrete time, infinite

\(^1\)ICOs have raised over 18 billion dollars, and the number is growing rapidly (Howell, Niessner and Yermack (2018)).
horizon model of investment. There are three types of agents: an entrepreneur, an intermediary, and consumers. A penniless entrepreneur has a project, which produces a stream of output when funded. The output price depends on his market power in the product market, which we capture with Nash bargaining. The intermediary funds any project with positive net present value (NPV), i.e. for which the present value of the revenue stream exceeds the required investment. Consumers, however, derive value from consuming the output directly. Thus, they fully internalize the consumer surplus and are willing to fund a different set of projects. To capture the idea that consumers and the intermediary might have different time horizons, consumers face an idiosyncratic liquidity shock, which leads them to discount the value of future output more heavily than the intermediary. This generates a demand for a resale market. Finally, in an extension, we introduce speculators who trade in the resale market based on different beliefs following Harrison and Kreps (1978).

There are five main results. First, intermediary funding suffers from inefficient underinvestment if consumers enjoy any surplus in the product market. Market power is a double-edged sword. The fact that consumers extract some surplus once a project is funded implies that a project with positive total surplus can have negative NPV, which prevents the project from getting intermediary funding in the first place. Hence, intermediary funding based on cash flows alone results in inefficient underinvestment.

The second main result is that direct funding by consumers, such as crowdfunding, can improve productive efficiency. In intermediary funding, consumers and financiers are distinct, and consumers cannot commit to pay more than the prevailing market price once the investment is sunk. Allowing consumers to directly fund a project acts as a commitment device, and enables some efficient projects, which the intermediary foregoes, to be funded. The relative benefit of crowdfunding over intermediary funding depends on the trade-off between consumer surplus and a liquidity discount. Since consumers face liquidity shocks, they heavily discount the future value of output. Hence, consumer funding is more likely to improve efficiency when the entrepreneur has little market power, and the project is short-term.
Our third main result is that an active resale market for the consumers’ claims, as in ICOs, can further improve efficiency. The resale market gives consumers an option to sell their claims to future consumers; this reduces the liquidity discount and allows consumers to fund more efficient projects than they would without the resale market. However, once the investment is sunk, future consumers will not pay more than the prevailing market price for the good, and so the price they are willing to pay for the claims does not reflect their surplus – the same commitment problem as in intermediary funding. Hence, crowdfunding with a resale market mitigates, but does not eliminate, the underinvestment problem.

The fourth main result is that speculation in the resale market can improve efficiency, but also can lead to inefficient overinvestment. Following Harrison and Kreps (1978), we introduce speculators who agree to disagree with consumers. Even when speculators value the claims less than consumers in all states, both consumers and speculators are willing to pay more so that they can sell them to the others when the state changes. By raising the price above consumers’ fundamental valuation, the speculative premium in the resale market can redress underinvestment in the funding market. It can also cause inefficient overinvestment when consumers retain little surplus in the product market, so that the future consumers’ commitment problem is not severe. Hence, speculation, often viewed as harmful, has nuanced efficiency implications.

Finally, we present various testable predictions. Due to the consumption benefit enjoyed by consumers, we predict that crowdfunded projects may appear to have lower profitability measured in terms of cash flow than intermediary funded projects. This does not imply that they are socially inefficient because consumers obtain an unobserved consumption benefit from the project. We suggest that the analysis of any crowdfunded projects should include an estimate of the consumption benefit. In addition, we note that even though there are no portfolio effects in our model (all agents are risk neutral), crowdfunding with resale necessarily induces a positive correlation between consumers’ portfolio performance and the consumption benefit. This should
be taken into account when evaluating the size restrictions on individual investments permitted under the 2012 JOBS act.

**Related Literature.** A large literature, building on Diamond (1984) considers incentive problems between a potentially informed or ill-behaving entrepreneur and potential funders. Given economies of scale, or co-ordination problems among investors, intermediaries arise as the natural funders of projects. Specifically, allocating monitoring rights to intermediaries can increase the total value of the investment to the funders. Strausz (2017) follows in this tradition by considering the additional benefit of crowdfunding, namely as a way of acquiring information about the eventual payoff of the project if there is demand uncertainty. The benefit of eliciting information in crowdfunding must be balanced against inefficiencies in controlling entrepreneurial moral hazard. Our focus differs from this literature because we abstract from incentive problems and asymmetric information between the entrepreneur and the funder and focus on the extent to which consumers and other funders’ valuations for projects differ. As we emphasize, consumers enjoy the benefit of low prices from any product they consume, which then reduces profitable cash flows. Crowdfunding is a way for them to ensure projects are undertaken even though they cannot commit to pay high prices.

We link market power to product market efficiency, and so our paper is related to Petersen and Rajan (1995), who show that credit market competition affects firms’ ability to get funding. Creditors are more likely to finance firms when they can extract more from the firms in the future, i.e. if credit markets are concentrated. Hence, the key idea that market power is a double-edged sword also applies to the credit market. Our paper differs from theirs in that we focus on marker power in the product market. Even if the credit market is in a pure monopoly, intermediaries will not fund a firm who has no market power. More importantly, we further study the mechanism through which consumers mitigate this problem by directly participating in funding decision, hence “consumers as financiers.”

Kumar, Langberg and Zvilichovsky (2019) consider crowdfunding as a way
for entrepreneurs to exercise market power and price discriminate. Specifically, consumers with higher valuations can be induced to participate in crowdfunding. While our work also focuses on market power, we consider how it affects the set of projects that are crowdfunded and intermediary funded.

There is a small (but rapidly growing) literature on crowdfunding and ICOs. Chemla and Tinn (2018) consider how reward-based crowdfunding provides valuable information to the entrepreneur. Specifically, consumer interest allows entrepreneurs to reduce demand uncertainty, the resulting real option is most valuable for innovative or uncertain goods, which they argue should be crowdfunded. Astebro et al. (2017) empirically and theoretically show how crowdfunding can be interpreted as a form of rational herding in which pledges are made in response to informed investment. They therefore do not view uninformed investment as a particular cause of concern. Further, Brown and Davies (2018) interpret the “all-or-nothing” feature of crowdfunding as a way of providing credible information about an underlying risky project. Cong and Xiao (2018) show how in a dynamic setting, the all-or-nothing feature can mitigate information cascades and provide information aggregation.

As we emphasize in our framework, ICOs permit crowdfunding with resale. Sockin and Xiong (2018) consider an equilibrium model of cryptocurrencies, in which speculation in the resale market can incentivize platform development. However, their focus is on the provision of resale trade — i.e., miners, as opposed to our focus in investment. Theoretically, ICOs have been examined by Chod and Lyandres (2018), who consider ICOs as a funding method that allows risk averse entrepreneurs to transfer risk to well diversified investors without giving up control rights. Catalini and Gans (2018) consider how an ICO may allow an entrepreneur to raise funding for a good that has a fixed value. To compare traditional funders and ICO funders, they assume that under traditional funding, the entrepreneur can commit to charge consumers their valuation of the good (i.e., they receive no surplus), but under an ICO, all purchases are made by token and so the supply of tokens implicitly determines the price of the good. By contrast, we consider the case in which the products’ pricing is independent of how the product is funded, and interpret
ICOs as a means to permit the resale of claims among consumers, and hence increase their willingness to fund the project. This distinction allows us to provide testable predictions on the cash-flow properties of projects that are crowdfunded with resale compared to those that are funded traditionally.\footnote{The benefits of ICOs in mitigating network externalities (i.e., affecting the realization of future demand) are developed by Li and Mann (2018). Bakos and Halaburda (2018, 2019) show that tradability of tokens helps overcome the coordination problem, and thus ICOs can be an attractive funding scheme when demand is uncertain. Empirical evidence on the properties of ICOs are presented in Momtaz (2018), while Lee, Li and Shin (2018) characterize how information and analysis is aggregated in these offerings. A further literature develops frameworks for valuing cryptocurrencies. For example, Cong, Li and Wang (2018) consider how the underlying tokens should be valued in the presence of network effects, as do Pagnotta and Buraschi (2018) and Sockin and Xiong (2018).}

Finally we observe that our work echos the debates on the role of market power on innovation, as in Arrow (1972) or Schumpeter (2017). Clearly, we present a much more applied version of these arguments.

1 Basic Model

We present a basic model to show how market power in the product market affects the productive efficiency of intermediary funding. We describe the setup in Section 1.1, provide the first-best funding outcome in Section 1.2, and determine the efficiency of the intermediary funding in Section 1.3.

1.1 Setup

Consider the following discrete time, infinite horizon model of investment. There are three types of agents: one penniless entrepreneur, an intermediary who uses cash flow metrics, and a continuum of consumers, whose measure is normalized to one. All agents are risk-neutral and have a zero time discount rate. Both the intermediary and the consumers have deep pockets and a zero opportunity cost of capital. At $t = 0$, the entrepreneur is endowed with a project, which costs a fixed amount $I > 0$. If the project is funded, it produces a perishable good each period for $t = 1, 2, \ldots$, until it fails. The project fails with probability $1 - \delta \in (0, 1)$ at each point in time. The marginal production...
Consumers derive utility $v > 0$ from consuming the output, while neither the intermediary nor the entrepreneur derives any value from it directly.

There are two separate markets: a funding market that operates at $t = 0$ and a product market that begins the next period at $t + 1$ onwards. In the funding market, the funder (either the intermediary or the crowd of consumers) makes a take-it-or-leave-it offer to the entrepreneur. (The take-it-or-leave-it assumption is for simplicity, and does not affect the tenor of our results.) In the product market, the entrepreneur sells the output to the consumers. To capture the entrepreneur’s market power, we assume that the price is determined every period by generalized Nash bargaining. The parameter $\alpha \in [0, 1]$ is the consumers’ bargaining power with the entrepreneur. When $\alpha = 1$, the consumer extracts full surplus; when $\alpha = 0$, the entrepreneur extracts full surplus. Here, $\alpha$ is a characteristic of the market and remains constant throughout the product’s lifespan.

1.2 First-Best Funding Outcome

Total surplus from the project is the sum of firm surplus and consumer surplus (Marshall (1890)). Denote by $V$ the expected present value of the consumer value from a project.

$$V := \sum_{\tau=1}^{\infty} \delta^\tau v = \frac{\delta}{1 - \delta} v. \quad (1)$$

Total surplus net of the initial investment is $V - I$.

Hence, first-best funding outcome is achieved if all projects with positive net total surplus (i.e. $V > I$) are funded and no project with negative net total surplus (i.e. $V < I$) is funded. Going forward, we refer to productive efficiency as the extent to which the first-best funding outcome is achieved. As depicted in Figure 1, the set of efficient projects is independent of $\alpha$, the entrepreneur’s market power in the product market.
1.3 Intermediary Funding Choice

A deep-pocketed intermediary with a zero cost of capital funds projects for which the present value of the expected revenue from the project exceeds the required initial investment $I$, i.e. the project has positive net present value (NPV).

When the intermediary funds the entrepreneur, the entrepreneur makes his investment and sells the output in the product market. The price of the output is determined by generalized Nash bargaining. Both the entrepreneur and the consumers have a zero outside option. If the entrepreneur does not sell the output, he receives nothing, and if the consumers do not buy the output, they receive nothing. Thus, at each $t = 1, 2, \ldots$, the price of the output $p$ is chosen to maximize

$$ (v - p)^\alpha p^{1-\alpha}. $$

Since the marginal production cost is zero, it is immediate that the price and thus the revenue each period is

$$ p = (1 - \alpha)v. $$
We note that if $\alpha = 0$, then consumers pay their valuation and the entrepreneur acts like a “perfectly discriminating” monopolist. If $\alpha = 1$, the product market price is zero and equal to the marginal cost of production – the entrepreneur produces in perfect competition. Let $V^b$ denote the present value of the revenue stream at $t = 0$, the valuation of the intermediary (“bank”).

$$V^b := \sum_{\tau=1}^{\infty} \delta^\tau p = (1 - \alpha) V. \quad (4)$$

The intermediary chooses to fund the project if and only if $V^b$ exceeds the initial investment $I$, i.e. the net present value is greater than zero or $V^b - I > 0$. Whether the intermediary funding achieves the first best depends on the entrepreneur’s market power in the product market. The following proposition summarizes this idea. (All proofs are in the Appendix.)

**Proposition 1.** If and only if $\alpha > 0$ so that consumers have any bargaining power in the product market, then the intermediary’s valuation $V^b$ (defined in Equation (4)) is strictly less than the total surplus $V$ (defined in Equation (1)). The intermediary fails to fund some projects with positive net surplus and negative NPV ($I \in [V^b, V]$), and hence there is inefficient underinvestment.

Intermediary funding based on the NPV rule can be inefficient. When the entrepreneur exercises limited market power, cash flow is a fraction of the value that it generates to the consumers. The difference between the total surplus and the intermediary’s valuation is the consumer surplus.

$$V - V^b = \alpha V. \quad (5)$$

Figure 2 provides an illustration of this result: the set of projects funded by the intermediary depends on $\alpha$. As consumers retain more surplus in the product market, the intermediary fails to fund efficient projects.

Market power in the product market is thus a double-edged sword. On the one hand, if the entrepreneur has less market power then consumers pay lower prices and enjoy a higher surplus. On the other hand, the lower the
entrepreneur’s market power, the lower the cash flows generated by the project and hence the NPV. This prevents the project from getting funding from the intermediary in the first place.

Here, the key friction which prevents efficient projects from being undertaken is that consumers cannot commit to pay their full valuation for the good once the investment has been sunk. Once the initial investment is sunk, consumers will only pay the prevailing market price. This friction arises because the intermediary and consumers are distinct in traditional funding.

Next, we study whether crowdfunding, which allows consumers to participate directly in funding new projects, can mitigate the underinvestment problem in intermediary funding.

2 Crowdfunding and Initial Coin Offerings

We introduce a model of crowdfunding and initial coin offerings. We describe the setup in Section 2.1, analyze the consumers’ crowdfunding decision without resale in Section 2.2, and study the implications of initial coin offerings, which we model as crowdfunding with an active resale market in Section 2.3.
2.1 Setup

Suppose the entrepreneur can crowdfund her project directly from consumers. In the funding market, consumers make a take-it-or-leave-it offer to the entrepreneur. In exchange for the funding, consumers receive rights to the entire stream of the output. Notice, that if the project is funded, consumers may also buy the output directly in the product market.

While the entrepreneur and the intermediary are infinitely lived, consumers have a shorter time horizon and are subject to an idiosyncratic “liquidity” shock. At each point in time, she receives the shock with probability \( \lambda \in [0, 1] \). Upon receiving the shock, she consumes everything and dies the next period, at which point new consumers are born. This timing assumption ensures that the measure of consumers is held fixed at one.

If there is an active resale market, consumers can trade their claims to the stream of the output. In particular, when one of the consumers who crowdfunds the project receives a liquidity shock, she can sell the claim to other consumers and consume the proceeds before she dies next period. To simplify the price formation mechanism, we assume that sellers in this resale market make a take-it-or-leave-it offer to buyers.\(^3\) Finally, we do not allow short sales.

\[
\begin{align*}
\text{Liquidity Shock} & \quad \text{realized} \quad \rightarrow \quad \text{Consume} \quad \rightarrow \quad \text{Shocked Consumers leave} \\
\text{Trade if there is a market} & \quad \rightarrow \quad \text{New consumers enter}
\end{align*}
\]

Figure 3: Life Cycle of a Consumer

\(^3\)The results would be qualitatively the same as long as sellers have any bargaining power with the buyers so that sellers can partly benefit from the resale market.
2.2 Crowdfunding without Resale

Let $V^c$ denote the value of the project to consumers.\(^4\)

\[
V^c := \sum_{\tau=1}^{\infty} \delta^\tau (1-\lambda)^{\tau-1} v = \left( \frac{1-\delta}{1-\delta+\delta\lambda} \right) V. \tag{6}
\]

Consumers are different from the intermediary in two respects. First, consumers take into account the consumer surplus. Second, consumers are subject to their idiosyncratic liquidity shock ($\lambda$). Consumers crowdfund the project if and only if $V^c$ exceeds the initial investment $I$. The liquidity shock prevents consumers from achieving first best.

**Proposition 2.** If and only if $\lambda > 0$ so that consumers face a liquidity shock, then consumers’ valuation without resale $V^c$ (defined in Equation (6)) is strictly less than the first best cutoff $V$ (defined in Equation (1)) and crowdfunding without resale fails to fund some projects with positive net surplus ($I \in [V^c, V)$), and hence there is inefficient underinvestment.

Crowdfunding without resale can be inefficient. Although consumers internalize their own surplus, they do not internalize the surplus of future consumers. The difference between $V$ and $V^c$ is the liquidity discount.

\[
V - V^c = \left( \frac{\delta\lambda}{1-\delta+\delta\lambda} \right) V. \tag{7}
\]

Consumers require compensation for the liquidity shock, i.e. the project must generate a sufficiently large value to justify the initial investment before they die.

We can compare the consumers’ valuation $V^c$ with the intermediary’s val-

\(^4\)At each $\tau \geq 1$, only $(1-\lambda)^{\tau-1}$ (not having received the shock until $t = \tau - 1$) fraction of consumers are the ones who crowdfund the project at $t = 0$; the others are born after the project is funded.
Hence, whether crowdfunding reduces inefficiency relative to the intermediary depends on the trade-off between consumer surplus and the liquidity discount.

**Proposition 3.** *If and only if*

\[ \alpha > \frac{\delta \lambda}{1 - \delta + \delta \lambda}. \]

*then the consumer surplus exceeds the liquidity discount, and the crowd funds strictly more projects than the intermediary. Since the crowd funds additional projects that have positive net total surplus but negative NPV \((I \in [V^b, V^c])\), crowdfunding without resale mitigates inefficient underinvestment.*

Whether crowdfunding can be more efficient than the intermediary funding depends on the condition in Equation (9). On the left hand side is the extent to which market power of the entrepreneur is limited in the product market,
captured by consumers’ bargaining power $\alpha$. The right hand side increases both in $\lambda$, the consumers’ liquidity shock and $\delta$, the continuation probability of the project each period. Intuitively, if consumers have more market power, then crowdfunding supports a larger range of projects because the consumer surplus is larger. Conversely, a higher probability of a liquidity shock makes crowdfunding less attractive because funding consumers do not internalize the surplus of future consumers. This implies that crowdfunding without resale is not suitable for longer-term projects.

The trade-off between intermediary funding and crowdfunding is illustrated in Figure 4. As the product market leaves more surplus for consumers, intermediary funding becomes less efficient whereas crowdfunding becomes more efficient.

One way to interpret the inefficiency of crowdfunding without resale is that there is a missing market. Consumers who crowdfund the project at $t = 0$ secure rights to the output of the project indefinitely. When consumers receive a liquidity shock, they cannot enjoy the consumption value from the next period onward, and so the rights to future output have no value to them. However, future consumers value the output. Next, we introduce a market in which consumers can trade claims for the future output.

2.3 Crowdfunding with Resale: Initial Coin Offerings

The existence of a secondary market raises consumers’ valuation for the project because of the resale option. When consumers receive a liquidity shock, they can sell the claim to future output to other consumers so that they can consume the proceeds before they die.

The specific application that we have in mind is Initial Coin Offerings. In an ICO, a new venture raises capital directly from consumers by issuing digital assets, called “tokens”. The tokens make it easier for consumers to re-trade their claims. This, of course, would help address the underinvestment problem of crowdfunding without resale: Can crowdfunding with resale achieve first best?
The inefficiency in intermediary funding arises because consumers cannot commit to pay a high price for the product after the investment cost is sunk, even though doing so would induce the intermediary to fund more projects. A similar friction still applies. Unlike the consumers who provide initial funding, new consumers can only commit to pay the prevailing market price \( p \) for the output each period. They cannot commit to pay their entire consumer surplus because they enter after the project is funded.

Let \( P \) be the price that new consumers can commit to pay for the claim to future output. Since sellers make a take-it-or-leave-it offer, this is the resale price of the claim. Then

\[
P := \sum_{\tau=t+1}^{\infty} \delta^{\tau-t} p = \frac{\delta}{1-\delta} p = (1-\alpha) V = V^b.
\]  

(10)

The resale price of the claim is the same as the intermediary’s valuation of the project. Notice that the consumers’ liquidity shock, \( \lambda \), does not affect the resale price: Future shocked consumers know they will be able to sell their own claims forward.

Given the resale price of the claim \( P \), the initial consumers’ valuation for the project is now given by

\[
V^r := \sum_{\tau=1}^{\infty} \delta^{\tau} (1-\lambda)^{\tau-1} (v + \lambda P).
\]  

(11)

Conditional on not having received a liquidity shock until \( t = \tau - 1 \), consumers always get \( v \) and additionally receive \( P \) in exchange of the claim if they get the shock at \( t = \tau \). Substituting Equation (10) into Equation (11), we have

\[
V^r = \left(1 - \frac{\alpha \delta \lambda}{1 - \delta + \delta \lambda}\right) V.
\]  

(12)

The valuation of consumers with resale \( V^r \) coincides with the first-best cutoff \( V \) if and only if \( \alpha = 0 \) or \( \delta = 0 \). In other words, crowdfunding with resale achieves first best if and only if either consumers have no bargaining
power \((\alpha = 0)\), in which case intermediary funding achieves alone is efficient, or consumers have no liquidity shock \((\lambda = 0)\), in which case crowdfunding without resale is efficient.

Even though it does not achieve first best, consumers' valuation with resale, \(V^r\), is at least as high as the consumers' valuation without resale \(V^c\) or the intermediary’s valuation \(V^b\). From Equations (4), (6), and (12),

\[
V^r = V^c + (1 - \alpha) \left( \frac{\delta \lambda}{1 - \delta + \delta \lambda} \right) V = V^b + \left( \frac{1 - \delta}{1 - \delta + \delta \lambda} \right) \alpha V. \quad (13)
\]

**Proposition 4.** Crowdfunding with resale (such as an ICO) is at least as efficient as crowdfunding without resale or as intermediary funding, i.e. \(V^r \geq \max \{ V^b, V^c \}\). If and only if either \(\lambda > 0\) or \(\alpha > 0\) so that consumers either have any bargaining power or face any liquidity shock, then crowdfunding with resale (ICO) fails to fund all projects with positive net surplus.

Hence, crowdfunding with resale always improves efficiency (at least weakly) relative to intermediary funding and crowdfunding without resale. The higher valuations are more efficient since the valuations \(V^b, V^c,\) and \(V^r\) do not exceed the first-best cutoff \(V\), meaning that the source of inefficiency is underinvestment, rather than overinvestment.

Although ICOs can improve efficiency by allowing resale, they do not achieve the first-best funding outcome. The inherent friction that consumers cannot commit to pay a high price after the investment is sunk cannot be overcome by simply opening a resale market for the claims. This commitment problem is reminiscent of the durable good monopolist problem presented by Coase (1972).

In Figure 5 we illustrate the benefit of introducing the resale market to crowdfunding. With resale, consumers can always fund more efficient projects than intermediary funding. As the entrepreneur’s market power in the product market decreases, the role of resale becomes limited due to future consumers’ lack of commitment.

One possible negative consequence of crowdfunding with resale, and one
much touted in the case of ICOs, is the possibility that prices do not reflect fundamental values. Specifically, there are concerns that prices are inflated because of speculation. Next, we study how speculation can affect the efficiency of ICOs.

3 Speculative Premia in Initial Coin Offerings

In this section we introduce investment uncertainty and study the effect of speculation on welfare in crowdfunding with resale. We describe the setup in Section 3.1, provide the benchmark results without speculation in Section 3.2, and show that speculation can address the underinvestment problem but also causes the overinvestment problem in Section 3.3.

3.1 Setup

To motivate speculation in the resale market driven by differences in beliefs (following Harrison and Kreps (1978)), we now introduce uncertainty in the investment. Specifically, at each $t = 1, 2, \ldots$, conditional on the project not
having failed yet, an aggregate state that can be either high or low \((s_t = s \in \{h, l\})\) is realized and publicly observed. The aggregate state affects the value of the project’s output to consumers. Consumers value the output as \(v\) in the high state, while the value is normalized to zero in the low state (i.e. \(v(h) = v\) and \(v(l) = 0\)).

At \(t = 1\), the state is high with probability one. From \(t = 2\) on, the state evolves according to a Markov chain. The transition matrix \(Q\) is

\[
Q = \begin{bmatrix}
q(h, h) & q(h, l) \\
q(l, h) & q(l, l)
\end{bmatrix} = \begin{bmatrix}
q_h & 1 - q_h \\
1 - q_l & q_l
\end{bmatrix},
\]

(14)

where \(q_s \in [0, 1]\) is the conditional probability of remaining in state \(s\) given that the project continues next period. We assume that the consumers’ beliefs are represented by the true transition matrix \(Q\).

We also allow a continuum of deep-pocketed and risk-neutral speculators to participate in the resale market. Speculators do not derive any value from consuming the output directly. Akin to the intermediary, speculators value the output each period at \(p = (1 - \alpha)v\), the market price of the output as presented in Equation (3). Speculators’ beliefs are represented by the transition matrix

\[
Q' = \begin{bmatrix}
q'_h & 1 - q'_h \\
1 - q'_l & q'_l
\end{bmatrix},
\]

(15)

where \(Q'\) may differ from \(Q\). Speculators and consumers agree to disagree. To highlight the effect of speculation, we assume that \(Q'\) is such that speculators’ valuation for the claim is always lower than the consumers’ valuation in each state, i.e. speculators are always more pessimistic than consumers (see Assumption 1 below). This implies that speculators would not participate in the resale market if there were not for the speculative opportunities.

The rest of the model is the same as that in 2.1. Recall that short sales are not allowed in the resale market. For simplicity, we assume \(\lambda = 1\), i.e consumers live for one period only. Before we delve into speculation in Section

\footnote{Note that this assumption will only make crowdfunding with resale less efficient, rather than more efficient.}
3.3, we briefly discuss how investment uncertainty affects different valuations. To do so, we re-derive first best, consumers’ and the intermediary’s valuations. We denote these valuations with uncertainty by a tilde.

### 3.2 Benchmark results

To determine the total surplus with investment uncertainty, we denote the conditional expectation of future consumer value from the project given the current state by \( V_s \) for \( s \in \{h, l\} \). Then for any \( t \geq 1 \), we have

\[
V_s := \mathbb{E} \left\{ \sum_{\tau=t+1}^{\infty} \delta^{\tau-t} v_\tau \bigg| s_t = s \right\}.
\]  

(16)

Recursively, \( V_h \) and \( V_l \) solve

\[
V_h = \frac{\delta q_h}{1 - \delta q_h} v + \frac{\delta (1 - q_h)}{1 - \delta q_h} V_l \quad \text{and} \quad V_l = \frac{\delta (1 - q_l)}{1 - \delta q_l} (v + V_h). \]

(17)

Here, \( V_h \) is the present value of \( v \) until the first time that the state changes to \( l \), at which point the value is \( V_l \). The \( V_l \) is the present value of \( v + V_h \), which is the value at the first chance the state changes to \( h \). It follows that

\[
V_h = \frac{q_h + \delta (1 - q_h - q_l)}{1 + \delta (1 - q_h - q_l)} \frac{\delta v}{1 - \delta};
\]

\[
V_l = \frac{1 - q_l}{1 + \delta (1 - q_h - q_l)} \frac{\delta v}{1 - \delta};
\]

(18)

which are well defined since \( 1 + \delta (1 - q_h - q_l) \geq 0 \).\(^6\)

Since the state at \( t = 1 \) is high \((s_1 = h)\) by assumption, the present value of all consumer value at \( t = 0 \) is

\[
\tilde{V} := \delta (v + V_h) = \left( \frac{1 - \delta q_l}{1 + \delta (1 - q_h - q_l)} \right) \frac{\delta v}{1 - \delta};
\]

(19)

The first-best is achieved when the project is funded if and only if \( \tilde{V} > I \).

---

\(^6\)Note \( 1 + \delta (1 - q_h - q_l) \geq q_h + \delta (1 - q_h - q_l) \), with equality if and only if \( q_h = 1 \); the RHS can be written as \((1 - \delta) q_h + \delta (1 - q_l) \geq 0\), which is strict if \( q_h = 1 \).
Since the revenue of the project is still a fraction $1 - \alpha$ of the consumer value each period, the linearity of the expectation implies that the intermediary’s valuation with investment uncertainty is simply

$$\tilde{V}^b = (1 - \alpha) \tilde{V}, \quad (20)$$

analogous to Equation (4).

To find the consumers’ valuation, recall that in this section, for simplicity, we assume $\lambda = 1$. Without resale, the funding consumers enjoy the output for the next period only. Hence, without resale, the consumer’s $t = 0$ valuation is

$$\tilde{V}^c = \delta v, \quad (21)$$

which is strictly less than $\tilde{V}$. It is higher than $(1 - \delta) \tilde{V}$, which we would obtain from substituting $\lambda = 1$ into Equation (6) because of the assumption that the state is high at $t = 1$.

With resale, the consumers’ valuation increases to

$$\tilde{V}^r = \tilde{V}^c + \delta (1 - \alpha) \tilde{V}_h = \delta (v + (1 - \alpha) \tilde{V}_h), \quad (22)$$

where $(1 - \alpha) \tilde{V}_h$ is the price that consumers at $t = 1$ are willing to pay for the stream of output conditional on the project continuation because only the funding consumers can commit to pay for their surplus. Again, the consumers’ valuation with resale $\tilde{V}^r$ is as high as $\tilde{V}^c$ and $\tilde{V}^b$. It is less than $\tilde{V}$ as long as the consumers have any bargaining power ($\alpha > 0$). The efficiency comparisons in Section 2 remain essentially unchanged.

### 3.3 Speculation: Heterogeneous Beliefs

Absent speculators, consumers’ willingness to pay for the claim in the resale market in each state $s \in \{h, l\}$ is $(1 - \alpha)$ fraction of $V_s$ given by Equation (18). Absent consumers, speculators’ valuation for the claim in each state is given similarly except replacing the consumers’ beliefs with the speculators’ beliefs.
As described earlier, we assume that speculators are always more pessimistic than consumers, i.e. speculators only participate for speculation.

**Assumption 1.** The conditional transition matrices $Q$ and $Q'$ are such that the speculators' valuation for the claim is lower than the consumers' valuation for the claim in both states, i.e.

\[
\frac{q_h + \delta (1 - q_h - q_l)}{1 + \delta (1 - q_h - q_l)} > \frac{q_h' + \delta (1 - q_h' - q_l')}{1 + \delta (1 - q_h' - q_l')},
\]

\[
\frac{1 - q_l}{1 + \delta (1 - q_h - q_l)} > \frac{1 - q_l'}{1 + \delta (1 - q_h' - q_l')}.
\]

To illustrate how speculation affects the resale price, consider when the speculator, whose valuation is lower than consumers in both states, would buy the claim in low state. The speculator would pay more for the claim than the consumers if the option to sell it back to the consumers in high state is sufficiently valuable. The fact that they can sell it at \((1 - \alpha)V_h\) to consumers in high state, makes speculators willing to pay

\[
P_l' = \frac{\delta (1 - q_l')}{1 - \delta q_l'} (1 - \alpha) (v + V_h),
\]

in the low state. This is strictly greater than consumers' valuation in the low state \(( (1 - \alpha)V_l)\) if and only if \(q_l' < q_l\). As long as speculators believe that the state will change to \(h\) more quickly than consumers do, they are willing to pay more for the claim in the low state than the consumers.

In turn, the high price that speculators are paying in low state increases the consumers' willingness to pay for the claim in high state.

\[
P_h = \frac{\delta q_h}{1 - \delta q_h} (1 - \alpha) v + \frac{\delta (1 - q_h)}{(1 - \alpha)} P_l'.
\]

Proceeding iteratively, one can construct prices in both states that reflect speculator's resale options.

**Proposition 5.** If and only if either \(q_l > q_l'\) or \(q_h < q_h'\) but not both, there is a
speculative premium in the resale market and the equilibrium resale price of the claim is higher than the consumers’ valuation and the speculator’s valuation in each state.

If \( q_l > q'_l \), the equilibrium resale price for the claim in each state is

\[
\begin{align*}
  P^*_h &= \frac{q_h + \delta \left(1 - q_h - q'_l\right) \delta (1 - \alpha) v}{1 + \delta \left(1 - q_h - q'_l\right) \delta (1 - \alpha) v}; \\
  P^*_l &= \frac{1 - q'_l}{1 + \delta \left(1 - q_h - q'_l\right) \delta (1 - \alpha) v}.
\end{align*}
\]

If \( q_h < q'_h \), the equilibrium resale price for the claim in each state is

\[
\begin{align*}
  P^*_h &= \frac{q'_h + \delta \left(1 - q'_h - q_l\right) \delta (1 - \alpha) v}{1 + \delta \left(1 - q'_h - q_l\right) \delta (1 - \alpha) v}; \\
  P^*_l &= \frac{1 - q_l}{1 + \delta \left(1 - q'_h - q_l\right) \delta (1 - \alpha) v}.
\end{align*}
\]

As in Harrison and Kreps (1978), the mere presence of a speculator, whose valuation is lower than the consumers in each state, can lead to higher prices for the claim in both states. This is because heterogeneous beliefs between the consumers and the speculator presents speculative opportunities. With the short-sale constraint, traders must buy the claim first to take advantage of these opportunities. The price of the claim rises to reflect the value of speculative opportunities, or “speculative premia.”

To see this more clearly, consider the following example with \( \delta = \alpha = v = q_h = q_l = .5 \), \( q'_h = .1 \) and \( q'_l = .4 \). Then the consumers’ valuation of the claim is .125 in each state and the speculator’s valuation is .07 and .12 in high and low states respectively. In each state, the consumers have a higher valuation for the claim than the speculator does. Notice that the condition in Proposition 5 is satisfied since \( q_l = .5 > q'_l = .4 \) and \( q_h = .5 > q'_h = .1 \).\(^7\) Therefore, the equilibrium price is .13 and .14 and the speculative premium is .005 and .015 in high and low states respectively.

\(^7\)In fact, Assumption 1 that the speculator’s valuation is lower than the consumers’ in both states ensures that the two inequalities in Proposition 5 never hold simultaneously.
This speculative premium affects consumers’ crowdfunding decision. Since the funding consumers can resell the claim at a higher price, they are willing to fund the project with a higher required investment. The consumers’ valuation with the speculative resale market $\tilde{V}^s$ is therefore

$$\tilde{V}^s = \tilde{V}^e + \delta P_h^* = \delta (v + P_h^*) .$$  \hspace{1cm} (28)

To determine the efficiency implication of speculation, we compare $\tilde{V}^s$ with the first-best cutoff $\tilde{V}$ (given by Equation (19)) and obtain

$$\frac{\tilde{V} - \tilde{V}^s}{\delta} = \alpha \frac{V_h}{\text{consumer surplus}} - \frac{(P_h^* - P_h)}{\text{speculative premium}}$$ \hspace{1cm} (29)

Whether speculation is efficient or not depends on the trade-off between consumer surplus and speculative premium.

**Proposition 6.** Suppose either $q_l > q_l'$ or $q_h < q_h'$ but not both. Define

$$\alpha_{\text{min}} := 1 - \frac{P_h}{P_h^*},$$ \hspace{1cm} (30)

where $P_h = (1 - \alpha)V_h$ and $V_h$ is given by Equation (18) and $P_h^*$ is given as in Proposition 5. Then $\alpha_{\text{min}} \in (0, 1)$, and speculation mitigates inefficient underinvestment if $\alpha \geq \alpha_{\text{min}}$, while it causes inefficient overinvestment if $\alpha < \alpha_{\text{min}}$.

Some speculation improves productive efficiency. As the entrepreneur’s market power decreases with the consumers’ bargaining power $\alpha$ increasing, the underinvestment problem from the lack of commitment of future consumers becomes more severe. Speculative premia, by raising the price at which initial consumers can sell the claim, mitigates the underinvestment problem.

However, as the entrepreneur’s market power increases so that the underinvestment problem is smaller, the speculative premium can reduce efficiency. Too much speculation overshoots the efficient valuation and encourages the initial consumers to fund projects even when the net total surplus is negative.
Speculative premia lead to an overinvestment problem.

In Figure 6, the speculative premium raises the required investment $I$ of the project for which initial consumers are willing to provide funding. As the consumers’ bargaining power in the product market increases, both the intermediary funding and the resale market become ineffective. Hence, a speculative premium improves efficiency. As the entrepreneur’s market power increases, both the intermediary funding and crowdfunding with resale can effectively fund efficient projects. Hence, a speculative premium leads to overinvestment; funding inefficient projects with negative net total surplus.

Recall the simple example from earlier with $\delta = v = q_h = q_l = .5$, $q_h' = .1$ and $q_l' = .4$. In this case, the ratio of $P_h$ to $P_h^*$ is given by $.07 / .13 = .54$, which is independent of $\alpha$. Hence, the speculative premium from heterogeneous beliefs mitigates underinvestment if $\alpha \geq .54$ but overshoots the efficient level and causes overinvestment if $\alpha < .54$. 

Figure 6: **Efficient and Inefficient Speculation**

![Figure 6: Efficient and Inefficient Speculation](image-url)
4 Discussion and Implications

In this section, we first touch on the robustness of our results in Section 4.1, then discuss marker power in Section 4.2, present testable implications in Section 4.3, and provide policy implications in Section 4.4.

4.1 Robustness

For clarity, our model is as stylized as possible. It is useful to consider its generality before turning to empirical and policy implications. A natural concern with a continuum of consumers is that this admits a free-rider problem as in Grossman and Hart (1980). Consumers may prefer to wait and consume the product when produced, and hence no projects will be funded. We note, however, that this problem only arises if no consumer is pivotal. This fragility of Grossman and Hart (1980) has been well-understood since Bagnoli and Lipman (1988) and subsequent work. To translate their ideas into our framework, consider a simple modification in which there is a large but finite number of consumers ($N$). A simple way to ensure that each consumer is pivotal is if the maximal amount each is willing to commit to a project is $I_N$. Then everyone is pivotal, and hence a Nash equilibrium in which all contribute clearly exists.

In our discussion of speculation we choose the off-the-shelf model of Harrison and Kreps (1978). Our assumption that investors disagree on the state transition matrix flows directly from their framework. We do so simply to show the interaction between the primary market funding decisions and the secondary market prices of the claims. Of course, any other modeling device that inflates the price of claims would generate similar results. We note in passing that differences in beliefs about the success probability of the project ($\delta$) would also lead to similar results.

Our model also abstracts away from frictions such as information asymmetry and moral hazard. The finance literature discusses various ways in which monitoring or screening mitigates the conflicts between entrepreneurs and financiers that these cause. In the face of such frictions, intermediary funding from intermediaries or venture capitalists clearly dominates funding from un-
informed consumers. However, it is also possible that funding from informed consumers dominates intermediary funding (as in Strausz (2017) or Chemla and Tinn (2018)). Our market power channel is different.

4.2 Market Power

The key idea of our paper is that the entrepreneur may not extract full surplus, in short may not have complete market power, in the product market. Although we use a generalized Nash bargaining setup for tractability, our setup can be interpreted more broadly.

Figure 7 presents a simple, downward sloping inverse demand curve and the graphical solution to the monopolist’s problem. Faced with a zero marginal cost of production, he will produce up to the point that the marginal revenue equals zero, which implies a monopolist quantity and price denoted by $P_m$ and $Q_m$. The profit that the monopolist can extract from the market is simply $P_m Q_m$, or the square under the demand curve. This also corresponds to the maximal amount that a monopolist would be willing to pay (i.e., investment) to serve the market. Now consider the consumer surplus. With a zero economic
cost of production, the gross consumer surplus is the entire area under the inverse demand curve or the triangle, given by \( P(0), Q_0 \) and the origin – with an area of \( \frac{P(0)Q_0}{2} \). This area corresponds to the “\( v \)” of our model. This is also the maximal amount that a central planner would pay to fund a project.

Now consider the ratio of the two areas, that is

\[
\frac{P_m Q_m}{P(0)Q_0}.
\]

(31)

This is the monetary profit as a fraction of the consumer surplus. The ratio of the two corresponds to our measure \((1 - \alpha)\), which is the amount that a producer can extract from the consumers. Note that if the monopolist is perfectly discriminating, then the ratio is just 1, whereas if the market is competitive, the ratio is 0. Our notion of bargaining power therefore captures the extent to which producers and consumers have different incentives in the funding market.

4.3 Testable Implications

We provide three testable implications. The first two are on characteristics of projects that are suitable for different funding methods. The third is on ex post performance.

Various characteristics affect the likelihood that a project gets intermediary funding or crowdfunding without resale. In Section 2, we analyzed three characteristics: the consumers’ bargaining power in the product market \((\alpha)\), the continuation probability of the project \((\delta)\), and the consumers’ liquidity shock \((\lambda)\). In Proposition 3, whether a project is sustainable for intermediary funding or crowdfunding (without resale) depends on the trade-off between the competitiveness \((\alpha)\), and the liquidity discount \((\frac{\delta\lambda}{1-\delta+\delta\lambda})\). The liquidity discount is high if the project has a long horizon, i.e. the project is likely to produce output in the far future, or if the consumers have a short horizon, i.e. their preference for the output is likely to change very quickly. Hence, a project is more attractive for crowdfunding (without resale) than intermediary
funding if market power outweighs the liquidity discount, or if the following hold:

i. The markup in the product market is low;

ii. The project has a short horizon;

iii. The consumers’ preference for the output is persistent.

Second, we analyze the implications of the resale market and speculation. In Section 3, we show that speculation mitigates underinvestment but can cause overinvestment. A project is more likely to suffer overinvestment due to speculation if either intermediary funding or crowdfunding without resale was already close to achieving first best, i.e. either the entrepreneur’s market power is high or liquidity discount was low in the first place, in other words if:

i. The output is sold in a non-competitive industry;

ii. The project has a short horizon.

Lastly, we consider ex post (observed) performance. We have demonstrated conditions under which a broader range of projects are attractive for crowdfunding rather than traditional methods. As the intermediary’s decision is based on an anticipation of future cash flows, it implies that crowdfunded projects will on average appear to have worse performance. However, even though the financial performance is worse, it does not mean that the projects are socially inefficient. Hence, in a matched sample of intermediary funded and crowd funded projects with the same investment:

i. Crowdfunded projects will have lower cash flows and profitability measures than intermediary funded projects.

ii. Crowdfunded projects with resale markets will have lower cash flows and profitability measures than crowdfunded projects without resale markets.
4.4 Policy Implications

Two natural policy implications arise from considering the interplay between the product and funding markets. First, we consider a lock-up period for the resale market. Second, we discuss potential implications of risk averse consumers.

Being a recent phenomenon, ICOs, or crowdfunding with an active resale market, face less stringent regulation than more established financing methods. In particular, the investors in IPOs are frequently restricted from trading immediately after their stocks become publicly available. Intuitively, a lock-up period helps insulate the funding decision from speculative premia in the secondary market. The lack of a similar regulation in ICOs can amplify the negative effect of speculation, ending up with funding inefficient projects.\footnote{Howell, Niessner and Yermack (2018) discuss a case of ICO, where the lock-up period is voluntarily imposed.} Imposing a lock-up period can help prevent overinvestment. Given our earlier testable implication, this regulation would be especially important when speculation is likely to cause overinvestment, i.e. the industry is less competitive or the project has a short horizon.

In our model, all agents are risk neutral so there is no natural reason for consumers to hold portfolios. However, we note that crowdfunding does have one particular characteristic – by construction, there is an induced correlation between financial wealth and consumption satiety. To see this, assume the econometrician has access to the entire population of consumers. (In this case, we do not have to consider the properties of the sample.) First, it is easy to see that projects that are intermediary funded will not have any obvious effect on the correlation of consumption with portfolio performance. However with crowdfunding, this is not the case.

**Proposition 7.** A project that is crowdfunded leads to covariance between the consumer’s portfolio performance and consumption. The sign of the covariance is the sign of $P_h - P_l > 0$.

It is difficult to know how to quantify the welfare effects of the increase
in variance of utility outcome that a correlation between consumption and
wealth induces. As far as we know, this was not part of the discussion around
the limits to investment mandated by the JOBS act. However, policy makers
should be aware of this natural consequence of crowdfunding with resale.

5 Conclusion

We have presented a simple model of crowdfunding that emphasizes the role of
consumer surplus. It is standard to take Fisher separation as given. However,
with crowdfunding, this distinction is no longer in place and so we should
expect the properties of crowdfunded projects to differ from those that are
funded by traditional methods.

We stress that crowdfunded projects are not different because firms and
entrepreneurs now have access to cheaper capital and face a smaller regulatory
hurdle, but because the criteria for “a good project” differ. Further, given that
consumers typically have shorter horizons than traditional funders, whether
the crowdfunding method allows them to resell their claims will affect the
types of projects that they are willing to invest in, and may also explain part
of the interest in ICOs.

Finally, we note that a long literature considers the benefit of patents
to encourage innovation and investment. The role of a patent is to protect
market share, and allow the innovating firm to extract rents or in other words
to reduce the consumer surplus. Crowdfunding in as much as it acts as a pre-
commitment by the consumers to buy the output of the project, can encourage
projects that might not be financed by traditional financing channels: It is
analogous to a patent issued by the consumer.
A Proofs

Proof of Proposition 1. It directly follows from the main text. □

Proof of Proposition 2. It directly follows from the main text. □

Proof of Proposition 3. It directly follows from the main text. □

Proof of Proposition 4. It directly follows from the main text. □

Proof of Proposition 5. Denote by $q(h)$ and $q(l)$ the probabilities of staying in state $h$ and $l$ respectively from the perspective of the owner of claim in each state in equilibrium. Then the equilibrium price $P^*_h$ and $P^*_l$ solve

$$P^*_h = \frac{\delta q(h)}{1 - \delta q(h)} (1 - \alpha) v + \frac{\delta (1 - q(h))}{1 - \delta q(h)} P^*_l;$$
$$P^*_l = \frac{\delta (1 - q(l))}{1 - \delta q(l)} (v + P^*_h). \tag{32}$$

The owner of the claim in each state is the trader who is willing to pay the most for the claim in that state. To determine the owner of the claim in high state, notice that

$$\frac{\partial P^*_h}{\partial q(h)} = \frac{\delta}{(1 - \delta q(h))^2} \left( (1 - \alpha) v - (1 - \delta) P^*_l \right). \tag{33}$$

Thus, $\frac{\partial P^*_h}{\partial q(h)} > 0$ if and only if

$$P^*_l < \frac{(1 - \alpha) v}{1 - \delta}, \tag{34}$$

which is always the case because the RHS is the present value of receiving $(1 - \alpha) v$ in all states. And from (32), we have

$$\frac{\partial P^*_l}{\partial q(l)} < 0. \tag{35}$$
\( P_h^* \) increases in \( q(h) \) holding \( P_l^* \) constant and \( P_l^* \) decreases in \( q(l) \) holding \( P_h^* \) constant.

Now, consider the four exclusive and exhaustive cases: (i) \( q'_h > q_h \) and \( q'_l \geq q_l \); (ii) \( q'_h \leq q_h \) and \( q'_l < q_l \); (iii) \( q'_h \leq q_h \) and \( q'_l \geq q_l \); (iv) \( q'_h > q_h \) and \( q'_l < q_l \).

In case (i), the speculator holds the claim in high state and the consumers hold the claim in low state. In case (ii), the consumers hold the claim in high state and the speculator holds the claim in low state. Hence, the price is higher than their independent valuations, i.e. there is a speculative premium in cases (i) and (ii). In case (iii), the consumers hold the claim in both states. In case (iv), the speculator holds the claim in both states. Hence, there is no speculative premium in cases (iii) and (iv).

To find the equilibrium price, we substitute the owner’s probability into Equation (32). In case (i), substituting \( q(h) = q'_h \) and \( q(l) = q_l \) into Equation (32) and solving for \( P_h^* \) and \( P_h^* \) yields Equation (27). In case (ii), substituting \( q(h) = q_h \) and \( q(l) = q'_l \) into Equation (32) and solving for \( P_h^* \) and \( P_h^* \) yields (26).

\[ \square \]

**Proof of Proposition 6** From Equation (30), speculation causes overinvestment (i.e. \( V^s > \bar{V} \)) if and only if

\[ \alpha V_h < P_h^* - P_h. \]  \hspace{1cm} (36)

Since \( P_h = (1 - \alpha)V_h \), we can write above as

\[ \frac{\alpha}{1 - \alpha} < \frac{P_h^*}{P_h} - 1. \]  \hspace{1cm} (37)

Rearranging this, we have

\[ \alpha < 1 - \frac{P_h}{P_h^*}. \]  \hspace{1cm} (38)

Hence, speculation mitigates underinvestment if \( \alpha \geq \alpha_{min} \) and causes overinvestment if \( \alpha < \alpha_{min} \).
Proof of Proposition 7}  Let $[\pi_h \pi_\ell]$ denote the unique stationary distribution, where

$$
\begin{align*}
\pi_h &= \frac{(1 - q_\ell)}{(1 - q_h) + (1 - q_\ell)} \quad (39) \\
\pi_\ell &= \frac{(1 - q_h)}{(1 - q_h) + (1 - q_\ell)} \quad (40)
\end{align*}
$$

If the consumers crowd fund a project, then the covariance of consumption with financial wealth is

$$(\pi_h v P_h + (1 - \pi_h) v P_\ell) - \pi_h v (\pi_h P_h + (1 - \pi_h) P_\ell).$$

which is positive if and only if

$$P_h \geq P_\ell.$$

Using the expressions presented in Equations 18, we obtain

$$P_h \geq P_\ell$$

$$q_h + \delta (1 - q_h - q_\ell) \geq (1 - q_\ell)$$

A sufficient condition is If $q_h + q_\ell > 1$. \qed
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