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Crowdfunding and Risk

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Abstract

This paper examines the role of rewards-based and equity-based crowdfunding in funding new businesses. In this model, crowdfunding is a unique technology that serves as a real option for production and eliminates downside risk. It affords entrepreneurs who face uncertain consumer demand a viable means of funding new projects. Crowdfunding performs well for projects with a high variability in demand and a low probability of success. Conversely, crowdfunding does not perform well for large projects with little variability in demand or for projects where the production side is uncertain.

Topics: Digital currencies and fintech; Financial markets; Financial services
JEL codes: G21, G24, G32

Résumé

Cette étude examine le rôle du financement participatif sous forme de prévente et par actions dans le financement des nouvelles entreprises. Je conçois un modèle dans lequel le financement participatif est une technologie unique qui représente une véritable option pour financer la production et qui élimine le risque de pertes. Ainsi, face à une demande incertaine, un entrepreneur dispose d'un moyen viable de financer de nouveaux projets. L'étude montre que le financement participatif fonctionne bien pour les projets caractérisés par une demande très variable et une faible probabilité de réussite, mais pas pour de gros projets où la demande varie peu ou des projets pour lesquels les incertitudes sont du côté de la production.

Sujets : Monnaies numériques et technologies financières; Marchés financiers; Services financiers
Codes JEL : G21, G24, G32

1 Introduction

Crowdfunding enables entrepreneurs to raise funds from a wide group of individuals, rather than a financial industry participant. Since its appearance as an alternative means of funding, crowdfunding has rapidly increased in popularity. As of 2023, popular venue Kickstarter reports having raised over $7B for projects, while equity crowdfunders WeFunder and FrontFundr report having raised over $500M and $120M for projects, respectively.[1] Crowdfunding's main advantage over traditional financing is that it allows entrepreneurs to reach out to a large mass of potential consumers at an early stage, where they receive a strong, credible signal of demand. This contrasts with traditional financing, where a single loan officer makes a decision with no precise signal on demand. These crowdfunding ventures tend to be small relative to most new businesses,[2] meaning that this new source of funding has the potential to increase the number and diversity of new products entering the market. In this paper, crowdfunding can serve as a successful means of both obtaining start-up funding and resolving uncertainty for entrepreneurs.

In this paper, crowdfunding takes one of two forms: rewards-based crowdfunding and equity-based crowdfunding. With rewards-based crowdfunding, entrepreneurs receive cash upfront from consumers who pre-purchase future goods. With equity-based crowdfunding, entrepreneurs offer equity stakes directly to consumers. Many existing models of crowdfunding focus on either rewards-based crowdfunding (Chemla and Tinn, 2020), equity-based crowdfunding (Brown and Davies, 2020), or treat the two as similar in nature (Lee and Parlour, 2022). This paper fills an important gap in the literature by explicitly modeling these two technologies, analyzing an entrepreneur's optimal use of the two, and comparing them to the conventional financial system.

[1] See, `https://www.kickstarter.com/help/stats`, `https://wefunder.com/pbc`, and `https://www.frontfundr.com/`.

[2] The average value raised on a successful project on Kickstarter is just over $30,000 (see: `https://www.kickstarter.com/help/stats`), much smaller than the median seed-stage VC deal of $3M, reported by Pitchbook in Q1 2023 (see `https://pitchbook.com/news/articles/venture-capital-monitor-charts-Q1-2023`).

I model entrepreneurship under uncertainty, where entrepreneurs face two frictions. First, entrepreneurs face uncertainty regarding consumer demand. Second, before any production can take place, entrepreneurs must raise funds, i.e., they face a cash-in-advance constraint. Entrepreneurs have the option to obtain these funds through either a crowdfunding technology, which provides credible information regarding demand, or through the traditional banking system, which does not reveal demand and uses increased interest rates to compensate for riskier projects.

In this paper, crowdfunding endows entrepreneurs with a real option to halt production if their cash-raising goals are not met. With this option, entrepreneurs are able to credibly commit to discontinue the project and return funds to consumers before beginning production. They do so based on a minimum revenue or minimum investment goal, which is endogenously set by the entrepreneur, publicly visible, and not alterable by the entrepreneur after it is initially announced. Using this commitment mechanism, crowdfunding transforms the total payoff of a project. Entrepreneurs no longer realize losses during unprofitable states and receive a payoff similar to a real call option. Based on this mechanism, I compare crowdfunding technologies to conventional funding methods.

I show that crowdfunding has advantages relative to traditional financing because entrepreneurs face uncertainty regarding demand for their products. While they may have confidence in their ability to produce, this does not necessarily imply that there is sufficient demand for them to have a profitable business. Traditionally, a portion of this uncertainty has been resolved by banks and venture capitalists (VCs), who have some ability to assess consumer demand. However, the conventional financing industry may not have the necessary expertise or willingness to screen very unique products, where they have little prior information on consumer demand. In my model, because crowdfunding solicits committed orders from consumers, entrepreneurs are able to refine their knowledge of consumer demand without similar risk.

While crowdfunding is well suited to resolve risk based on consumer demand, the same is not true for risk based on production costs. When entrepreneurs use the banking system, high production costs may result in default. For the bank, this risk is similar in nature to demand-side risk. Unlike with banking, production cost risk both removes crowdfunding's principle benefits and introduces new weaknesses. With crowdfunding, consumers pay the entrepreneur in advance for the good. If the entrepreneur exhausts their funding without completing these orders, consumers do not receive their goods and payments are not returned. When this risk exists, consumers decrease their willingness to pay in a risk-neutral manner, decreasing the total profitability and further increasing the likelihood of project failure. This prediction highlights the importance to entrepreneurs of demonstrating production ability and past success when advertising new crowdfunding projects.

1.1 The Crowdfunding Process

Crowdfunding can be classified based on what the individuals who fund the projects receive in return. Two of these are the focus of this paper. The first of these are "perks" or "rewards" based projects. In these projects, the funders receive some form of good or service in return for providing the project with funding. In essence, these are somewhat similar to prepaying for a good prior to receiving it. The second group of projects are equity-based crowdfunding. These function similarly to conventional financial instruments but may market to consumers as well as traditional early-stage investors. Funders receive an equity stake in the project, rather than a consumption good. Finally, while not the focus of this paper, additional classes of crowdfunding projects may issue either debt-like stakes or are charitable or philanthropic in motivation.

While the process behind crowdfunding is far from uniform across venues, there are many traits that tend to be common among rewards- and equity-based campaigns, which this paper seeks to explain.[3]

[3] A more complete explanation of many of the possible iterations of crowdfunding can be found in Tomczak and Brem (2013) and Agrawal et al. (2014).

Rewards-based crowdfunding efforts typically offer a series of goods or rewards in advance of production, which has not yet occurred. The entrepreneur outlines a schedule of prices, whereby anyone who contributes at least a specific amount receives some predefined benefit. If the funding campaign involves physically producing some consumption good, the schedule of benefits corresponds to the backers receiving some quantity of the final production. The entrepreneur sets a price and is able to see the demand at that price, before production even begins, which removes inventory risk. The important distinction between rewards-based crowdfunding and other methods of funding is that the entrepreneur receives a strong, credible signal of demand from consumers.

Second, rewards and equity-based crowdfunding efforts fall into one of two groups depending on whether there is a minimum revenue required before the project receives funding. In an "all-or-nothing" or "goal-based funding" campaign, the entrepreneur sets a minimum total revenue or investment goal. If the total amount pledged falls below this goal, the entrepreneur does not receive any of the pledged funds, and is not required to produce or continue the venture. Conversely, in a "flexible" funding campaign, the entrepreneur receives funds and must produce to fill their orders regardless of how much they receive in total.[4] The use of minimum funding goals interacts positively with the demand signal received by the entrepreneur. If, for demand below a certain volume, the entrepreneur believes the project would earn a loss, this can typically be prevented altogether by setting an appropriate minimum funding goal. The risk of project failure due to a lack of consumer demand can be either lowered or negated altogether.

1.2 Existing Literature

Theoretical work on crowdfunding studies crowdfunding as a method for entrepreneurs to cover some advanced cost of production (Rubinton, 2011; Belleflamme et al., 2014). This paper extends these papers by allowing the endogenous selection of crowdfunding from among

[4] Empirically, the difference between these two methods is studied by Cumming et al. (2020).

conventional fundraising methods and by focusing on crowdfunding investors as consumers who have no outside motives other than consumption or investment returns. Chemla and Tinn (2020) study crowdfunding as a means of fundraising by entrepreneurs in order to overcome a moral hazard constraint.[5] Similarly, Catalini and Gans (2018), Li and Mann (2018), and Malinova and Park (2018) study initial coin offerings (ICOs) and token-based funding, which can serve a function similar to crowdfunded equity stakes. This paper is complementary to these papers in that it analyzes both rewards-based and equity-based crowdfunding efforts in comparison to the conventional banking system.

The model in this paper supports existing empirical findings on crowdfunding, which focus on crowdfunding as a method of vetting projects. Agrawal et al. (2011) and Peng and Zhang (2021) highlight the benefits from geographic and social proximity in the crowdfunding process.[6] Similarly, Kim and Viswanathan (2018), Bai et al. (2022), and Zhang et al. (2023) show that disclosure of investors, and having trusted experts among investors, can benefit equity-based crowdfunding projects. Finally, in line with the vetting hypothesis, Kuppuswamy and Bayus (2018) find that the amount raised in crowdfunded projects is highest during the first and final weeks of the project.

This model highlights how crowdfunding can mitigate uncertainty regarding consumer demand but may struggle with uncertainty regarding entrepreneur's abilities. This result is complementary to Xu (2018), who finds that projects that benefit most from early feedback benefit most from the crowdfunding process. Similarly, while Mollick (2014) finds that projects with lower goals and shorter funding periods were associated with higher probabilities of success, which could be because these projects were viewed as less likely to have delays or logistical problems in completing production. Results for equity-based crowdfunding are similar, where projects with strong roadmaps and rich descriptions are more likely to be

[5] Empirically, the moral hazard hypothesis and its relation to fraud is studied by Cumming et al. (2021).

[6] Interestingly, existing literature on conventional financing finds that loan rates may decrease with geographical dispersion, as in Degryse and Ongena (2005). Further, Degryse and Ongena (2005) find that adverse selection does not increase significantly over wider distances.

successful (Ahlers et al., 2015; Koch and Siering, 2015), indicating that entrepreneurs seek to mitigate uncertainty about their production ability.

This paper extends the existing literature on entrepreneurship and barriers to entry in credit markets.[7] This paper posits equity- and rewards-based crowdfunding as a means of funding new projects when compared to the traditional financial system. Equity crowdfunding and similar methods, such as ICOs, can enable new projects that are not served by angel investing, VCs, or other means of funding (Hornuf and Schwienbacher, 2016; Dolatabadi et al., 2021; Garratt and Van Oordt, 2022). Existing banking systems may ration credit to new projects because of incentive problems (Stiglitz and Weiss, 1981), monitoring costs (Williamson, 1987), and collateral constraints (Besanko and Thakor, 1987). In this paper, true credit rationing (in the sense of Stiglitz and Weiss (1981)), where ex-ante identical loan seekers are either afforded or denied credit, does not occur. However, in some cases, borrowers who would be denied credit from the banking system will be able to find funding for their projects through crowdfunding. In this sense, potentially profitable projects that were passed over by the banking system or the angel investors and VCs will be able to enter production as a result of the new technology.

2 Model

I construct a single period model of consumer demand and entrepreneurship. Consumers are represented by a single aggregate demand curve for a consumption good. This consumption good is produced by an entrepreneur, who must seek funding before production. This funding comes either from the conventional banking system or rewards-based or equity-based crowdfunding.

[7]The model presented in this paper, which differentiates banking and crowdfunding technologies, also parallels existing literature differentiating banking and venture capital. Further literature reviews on venture capitalists can be found in Kaplan and Strömberg (2001) and Da Rin et al. (2013).

2.1 Consumers

A group of infinitesimal consumers demand the good produced by the entrepreneur. The aggregate demand from these consumers is arranged onto a single demand curve. Consumers' aggregate demand has two elements that affect it. First, consumers are risk neutral and discount their willingness to pay linearly with the risk that they do not receive a good after they have paid for it. That is to say they assess the probability that they will receive a good after irreversibly paying for it, and discount their valuation of it appropriately. Second, consumers have a random shock to demand, ϵ. Neither individual consumers nor the entrepreneur are able to coordinate to view this shock to demand before all consumers submit orders to the entrepreneur. The demand shock, ϵ, which is also referred to as the "state," is distributed:

$$\epsilon = \{\sigma, -\sigma\} \text{ with } Pr = \{p, (1-p)\} \tag{1}$$

The shock, σ, represents the size of demand risk. For simplicity $\epsilon = \sigma$ is referred to as the "high-demand" state, while $\epsilon = -\sigma$ is referred to as the "low-demand" state.

Given the shock and the probability that the project succeeds, aggregate consumer demand at any price P is denoted:

$$Q(\epsilon) = \phi - \frac{B \cdot P}{\theta} + \epsilon \tag{2}$$

In the aggregate demand function, ϕ represents the size of the project, while B represents price sensitivity. θ represents the probability that consumers receive goods from the entrepreneur if they pay irreversibly for them prior to production.

2.2 Entrepreneurs

An entrepreneur has exclusive access to a production technology for the consumption good, referred to as her project. Entrepreneurs require cash in advance in order to produce and must cover a fixed cost, F. Once the entrepreneur pays the fixed cost, the demand state ϵ becomes known to all parties. After paying the fixed cost, the entrepreneur has access to a constant returns to scale production technology with a marginal cost of c for each unit produced.

Entrepreneurs are unable to pay the fixed cost F themselves. Instead they must obtain outside funding. They are able to obtain cash from one of three sources: a bank, rewards-based crowdfunding, or equity-based crowdfunding.

The entrepreneur's problem has two stages. First, she chooses a funding method in order to maximize her expected profit. Second, she maximizes her expected profit within the funding method selected in the first stage. The funding technologies and their respective profit functions are described below.

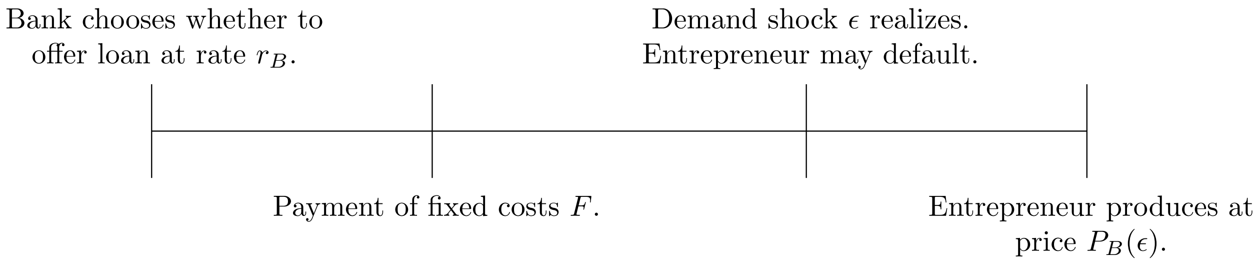
We assume that entrepreneurs are not subject to moral hazard. In the context of this model, this means that entrepreneurs do not misappropriate funds they have received and they do engage in production if they are able to do so profitably.[8] That is to say that entrepreneurs do not engage in crowdfunding with the intention of misappropriating funds, regardless of whether the project could be successful.

2.3 Banking

A representative bank is able to offer loans to entrepreneurs at an interest rate r_B. The bank is aware of the structure of consumer demand but does not view the demand shock before the entrepreneur pays her fixed costs. If the entrepreneur approaches it, the bank chooses whether to supply the entrepreneur credit to cover her fixed costs. After paying the fixed cost, the realization of the demand shock, ϵ, is known to both the entrepreneur and the bank. If the entrepreneur is unable to produce enough to cover the value of the loan and interest, they default and no value is recovered from the project. If the entrepreneur can produce profitably, they may do so and sell the completed output to consumers.

[8] For an analysis of the role of moral hazard in the crowdfunding process, see Chemla and Tinn (2020).

Figure 1: Banking Timeline



When the entrepreneur funds with banking, the bank selects a rate (r_B) on the loan such that it earns zero profit in expectations. Second, the entrepreneur pays her fixed costs (F) and the demand shock (ϵ) is realized. If the entrepreneur is unable to earn at least zero profit given the demand shock, she defaults. If she does not default, the entrepreneur selects a price $P_B(\epsilon)$ to maximize her profit.

The bank chooses both whether to offer an initial loan and the rate to charge. The bank sets the loan rate r_B competitively such that it earns zero profit in expectation. To represent the underlying cost of funding, the bank incurs a cost $(1 + r_F) \cdot F$ to source the fixed costs for the entrepreneur.

If the entrepreneur is able to pay back the bank in both states, the bank receives a payoff of $(1 + r_B) \cdot F$ with certainty, and therefore $r_B = r_F$. If the entrepreneur is only able to pay back the bank when $\epsilon = \sigma$, the bank receives a payoff of $(1 + r_B) \cdot F$ with probability p and 0 with probability $1 - p$. The zero profit rate is then given by $r_B = \frac{1+r_F}{p} - 1$.

Given that the bank chooses to offer the initial loan, the entrepreneur selects $P_B(\epsilon)$ in each state ϵ where she can earn a positive profit to maximize:

$$\pi_B = Q(\epsilon) \cdot (P_B(\epsilon) - c) - F \cdot (1 + r_B) \tag{3}$$

Figure 1 illustrates the timing of the entrepreneur's banking decisions.

2.4 Rewards-Based Crowdfunding

If the entrepreneur chooses rewards-based crowdfunding technology she first announces the price P_R at which she is willing to sell her product. The entrepreneur receives orders for her product, based on the consumers' aggregate demand curve, which she must then fill. Unlike the bank, where entrepreneurs pay an interest rate based on the costs incurred, crowdfunders pay a fee based on their total revenue. This fee, r_R, is set exogenously within the model, and I do not formally study the competitive structure between rewards-based crowdfunding platforms.[9]

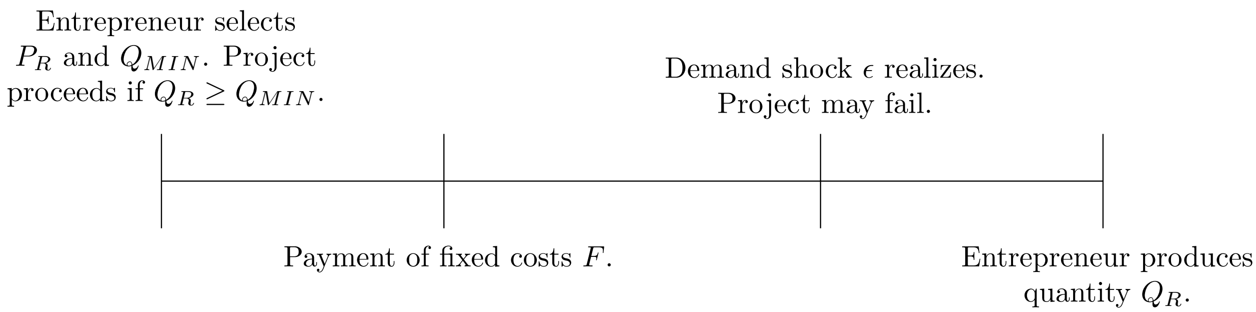
With rewards-based crowdfunding, the entrepreneur may set a minimum quantity of orders they must receive before receiving any cash from consumers. If the entrepreneur receives funding below this level, the funds are returned to the consumers, the entrepreneur is not obliged to produce, and all agents receive a payoff of 0. The entrepreneur may select this quantity Q_{MIN} at the same time as she selects the price. This level is visible to all consumers and is unchangeable once it has been set. If the entrepreneur sets Q_{MIN} such that she is able to fully cover her costs in all states ϵ where $Q(\epsilon) \geq Q_{MIN}$, consumers have no risk of losing their money, and $\theta = 1$.

Alternatively, if the entrepreneur sets Q_{MIN} such that she is unable to cover her costs after she receives a number of orders where $Q(\epsilon) \geq Q_{MIN}$, the project fails and no funds are recoverable by either consumers or the entrepreneur. Consumers internalize the probability of a project failing in this manner and discount their willingness to pay accordingly. If this failure occurs only in the low-demand state, consumers discount such that $\theta = p$. If failure occurs in both states, $\theta = 0$ and the project is non-viable.

The minimum funding level differentiates crowdfunding from other pre-ordering technologies. By allowing producers to credibly return funds in the event of insufficient demand, consumers do not discount their willingness to pay based on demand-side risk. In this model, if producers were unable or unwilling to set a minimum funding level, consumers would discount their willingness to pay based on the probability that they do not receive a final product. In that sense, entrepreneurs with higher risk would necessarily charge a lower

[9]In practice, this fee can be important in an entrepreneur's decisions. As of 2023, the combination of Kickstarter's own fee and their payment processing fee start at 8% of revenue for U.S. projects. See https://www.kickstarter.com/help/fees.

Figure 2: Rewards-Based Crowdfunding Timeline



When the entrepreneur funds with rewards-based crowdfunding, she selects a price (P_R) and minimum revenue goal (Q_{MIN}) to maximize her expected profit. The project proceeds and the entrepreneur pays her fixed costs (F) if $Q_R \geq Q_{MIN}$. Instead, if $Q_R < Q_{MIN}$ all funds are returned to consumers and no costs are incurred. At this point the demand shock (ϵ) is realized, though the price and quantity have already been set. If the entrepreneur is able to produce the quantity that has been demanded, given the price she has set, she does so; otherwise the project fails.

price to compensate consumers for that risk. The use of a minimum funding level removes this risk from the equilibrium, rather than simply shifting it to another agent.

The entrepreneur's problem is to select a single price P_R and a minimum quantity Q_{MIN} to maximize the expectation of her profit function:

$$\pi_R = \begin{cases} Q(\epsilon) \cdot (P_R \cdot (1 - r_R) - c) - F & Q(\epsilon) \geq Q_{MIN} \\ 0 & Q(\epsilon) < Q_{MIN}. \end{cases} \tag{4}$$

Figure 2 illustrates the timing of the entrepreneur's rewards-based crowdfunding decisions.

2.5 Equity-Based Crowdfunding

With equity-based crowdfunding, consumers may purchase an equity stake of total size F covering the fixed costs. In exchange, they receive a stake χ in the project's profits.

A fraction μ of consumers wish to fund the project for an amount $\phi + \epsilon$. Thus, the total amount of funds available to the entrepreneur in any state is $I_E = \mu(\phi + \epsilon)$. If the funds available exceed the entrepreneurs fixed costs, only a total of F is invested and excess funds are returned to consumers. Consumers must earn an exogenous expected rate of return $1+r_E$

on their investment, representing the opportunity cost of investment funds to consumers. In line with the fact that equity inherently bears a risky return, I assume that $r_E > r_F$.

As with rewards-based crowdfunding, equity-based crowdfunding allows for a publicly visible, unchangeable, minimum funding amount, denoted I_{MIN}. If investment from consumers I_E is below this minimum amount, all funds are returned, no losses are incurred, and no output is produced.

Similar to before, if the entrepreneur sets I_{MIN} such that she is unable to produce profitably in a state ϵ where $I_E \geq I_{MIN}$, the project fails and neither the entrepreneur nor consumers are able to recover any investment. Unlike rewards-based crowdfunding, consumers only pay for goods after fixed costs have been recovered, and thus even if the project fails when $I_E \geq I_{MIN}$, $\theta = 1$.

The entrepreneurs problem is to set $P_E(\epsilon)$ for each state ϵ and choose a minimum investment amount I_{MIN} to maximize the expectation of her profit function:

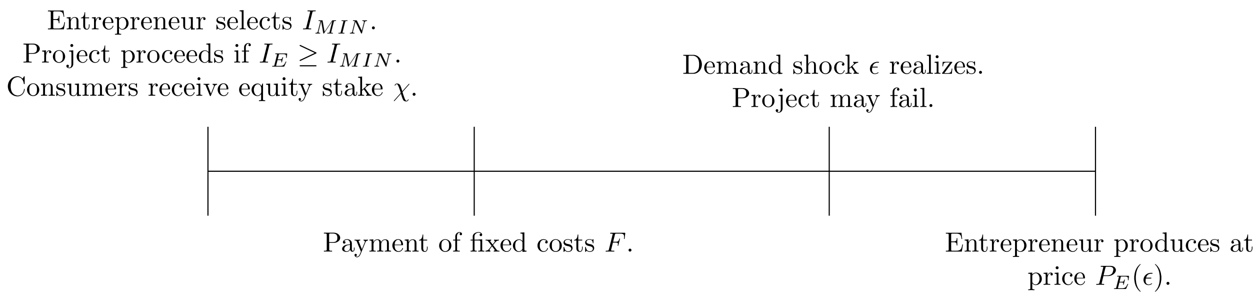
$$\pi_E = \begin{cases} (1-\chi)Q\left(\epsilon\right) \cdot \left(P_E(\epsilon) - c\right) & I_E(\epsilon) \geq I_{MIN} \\ 0 & I_E(\epsilon) < I_{MIN} \end{cases} \tag{5}$$

The fraction of the projects' payoff given to investors, χ, is such that consumers earn zero profit in expectation from their investment alone. Consumers take their future consumption as given and do not act strategically to coordinate their consumption and investment decisions. This value χ solves:

$$E_\epsilon \left[\chi \cdot Q\left(\epsilon\right) \cdot \left(P_E(\epsilon) - c\right) - (1 + r_E) \cdot F | I_E(\epsilon) \geq I_{MIN}\right] = 0 \tag{6}$$

The entrepreneur is restricted to offering 100% of the project's return to consumers as equity, and thus $\chi \leq 1$ serves as a constraint. Figure 3 illustrates the timing of the entrepreneur's equity-based crowdfunding decisions.

Figure 3: Equity-Based Crowdfunding Timeline



When the entrepreneur funds with equity-based crowdfunding, she selects a minimum investment amount (I_{MIN}) to maximize her expected profit. The project proceeds and the entrepreneur pays her fixed costs (F) if $I_E \geq I_{MIN}$. If so, consumers receive a fraction of the project's realized profits (χ). Instead, if $I_E < I_{MIN}$ all funds are returned to consumers and no costs are incurred. Next, the demand shock (ϵ) is realized. If the entrepreneur is unable to earn at least zero profit given the demand shock, the project fails. If the project does not fail, the entrepreneur selects a price $P_E(\epsilon)$ to maximize her profit.

3 Equilibrium

In this section I establish an equilibrium, which consists of (1) a solution to the entrepreneur's banking problem; (2) a solution to the entrepreneur's rewards-based crowdfunding problem; (3) a solution to the entrepreneur's equity-based crowdfunding problem; and (4) a solution to the entrepreneur's funding selection problem.

Definition 1 (Definition of an Equilibrium) *An equilibrium consists of solutions to the entrepreneur's four problems:*

1. ***The banking problem:*** *Prices $P_B^*(\epsilon)$ for each state ϵ, s.t. $\{P_B^*(\sigma), P_B^*(-\sigma)\} = max_{\{P_B(\sigma), P_B(-\sigma)\}}\pi_B$ where π_B is given by Equation 3.*

2. ***The rewards-based crowdfunding problem:*** *A price P_R^* and minimum funding goal Q_{MIN}^*, s.t. $\{P_R^*, Q_{MIN}^*\} = max_{\{P_R, Q_{MIN}\}}\pi_R$ where π_R is given by Equation 4.*

3. ***The equity-based crowdfunding problem:*** *Prices $P_E^*(\epsilon)$ for each state ϵ, and minimum funding goal I_{MIN}^*, s.t. $\{P_E^*(\sigma), P_E^*(-\sigma), I_{MIN}^*\} = max_{\{P_E(\sigma), P_E(-\sigma), I_{MIN}\}}\pi_E$ where π_E is given by Equation 5.*

4. ***The funding selection problem:*** *A funding method* $M \in \{B, R, E\}$*, s.t.* $\pi_M = max\{\pi_B^*, \pi_R^*, \pi_E^*\}$*, where* π_B^**,* π_R^**, and* π_E^* *are the expected profits resulting from the solutions to the entrepreneur's banking, rewards-based crowdfunding, and equity-based crowdfunding problems, respectively.*

3.1 Banking Problem

The entrepreneur's access to banking technology serves as a baseline in this model, representing her access to funds before the crowdfunding technology became available. The entrepreneur's banking problem can be analyzed in two parts using backwards induction: first, the entrepreneur's optimal prices in each state ϵ determine the profitability of the project; second, the project's profitability in each state determines the rate charged by the bank and the overall feasibility of the project.

First, the entrepreneur determines her optimal pricing solution. Since the banking technology allows for the discovery of the demand shock, ϵ, prior to production, the entrepreneur is able to maximize her profit separately in each state. The pricing equations that maximize Equation 3 are given by:

$$P_B^*(\epsilon) = \frac{\phi + \epsilon + Bc}{2B} \tag{7}$$

Inserting these prices into the consumers' demand functions and the entrepreneur's banking profit function give her the expected profit from banking.

Next, the entrepreneur determines the feasibility of the project. Consider a project that is able to pay back the loan in both states. The entrepreneur is charged a rate of $r_B = r_F$ This project is constrained such that it is viable if the entrepreneur is able to pay back the loan when demand is low, i.e., $\epsilon = -\sigma$. Given the entrepreneur's optimal pricing solutions, her project is viable in all states if:

$$\phi \geq \underline{\phi}_B^A \equiv Bc + \sigma + 2\sqrt{BF(1 + r_F)} \tag{8}$$

Finally, consider a project that is only able to pay back the loan when demand is high. In this case, the bank is only paid back with probability p, and it charges the entrepreneur a rate of $r_B = \frac{1+r_F}{p} - 1$. This project is constrained such that it is viable if the entrepreneur is able to pay back the loan when demand is high, $\epsilon = \sigma$. Given the entrepreneur's optimal pricing solutions, her project is viable in the high-demand state if:

$$\phi \geq \underline{\phi}_B^H \equiv Bc - \sigma + 2\sqrt{\frac{BF(1+r_F)}{p}} \tag{9}$$

Overall, the project is then viable using bank lending if it is larger than at least one of the thresholds:

$$\phi \geq \underline{\phi}_B \equiv min\{\underline{\phi}_B^A, \underline{\phi}_B^H\} \tag{10}$$

Depending on which threshold is lower, bank funding can take one of two forms. If $\underline{\phi}_B^H < \underline{\phi}_B^A$, banks are willing to fund risky projects. Banks will fund projects with ϕ such that $\underline{\phi}_B^H \leq \phi < \underline{\phi}_B^A$ and expect them to default when demand is low. Alternatively, if $\underline{\phi}_B^H \geq \underline{\phi}_B^A$, banks are only willing to fund projects that do not default.

In either case, projects below the size of $\underline{\phi}_B$ cannot be funded through bank lending. Similar to existing literature on credit rationing (such as Williamson (1987)), even when the bank is able to raise its interest rate to earn at least zero profits, some projects will not be funded. In this model, for projects of sufficiently small size, there are no interest rates that will both cover the bank's risk and yield a positive profit to the entrepreneur.

3.2 Rewards-Based Crowdfunding Problem

The entrepreneur's rewards-based crowdfunding problem is to set a price, P_R, and a minimum quantity goal, Q_{MIN}, prior to discovering the demand shock. If her total order quantity is below Q_{MIN}, funds are returned and she does not produce. The rewards-based crowdfunding equilibrium can then take one of two forms: (1) the entrepreneur sets Q_{MIN} such that she receives funds in all states, or (2) the entrepreneur sets Q_{MIN} such that she only receives funds when demand is high, $\epsilon = \sigma$. The entrepreneur selects whichever of these two forms yields a greater profit in expectation.

If the entrepreneur wishes to receive funds in all states, she sets a combination of P_R and Q_{MIN} such that $Q(-\sigma) \geq Q_{MIN}$. There are two possibilities for the entrepreneur. If the entrepreneur is able to profitably produce in both states, consumers receive the product with certainty, and $\theta = 1$. If the entrepreneur is unable to profitably produce in both states, consumers pay for the product but only receive it if demand is high, and $\theta = p$. In equilibrium, this latter case is never optimal and the entrepreneur never selects Q_{MIN} such that $Q(-\sigma) \geq Q_{MIN}$ if the project is unprofitable with low demand ($\pi_R(-\sigma) < 0$).

The entrepreneur's optimal price when she sets Q_{MIN} such that $Q(-\sigma) \geq Q_{MIN}$ is:

$$P_R = \frac{(1-r_R)(p(\phi+\sigma)+(1-p)(\phi-\sigma))+Bc}{2(1-r_R)B}, \tag{11}$$

while her choice of Q_{MIN} must satisfy:

$$Q_{MIN} \leq \phi + \sigma - \frac{(1-r_R)(p(\phi+\sigma)+(1-p)(\phi-\sigma))+Bc}{2(1-r_R)} \tag{12}$$

For this equilibrium to be viable, the project must be profitable in both states, which occurs when:

$$\phi \geq \underline{\phi}_R^A \equiv \frac{Bc+\sigma(1-r_R)+2\sqrt{(1-r_R)FB+p^2(1-r_R)^2\sigma^2}}{1-r_R} \tag{13}$$

Alternatively, the entrepreneur may set Q_{MIN} such that $Q(-\sigma) < Q_{MIN}$, and she only receives sufficient funds when demand is high. Since consumers' funds are returned if demand is low, they do not risk losing their funds and therefore $\theta = 1$. In this case, her optimal price is:

$$P_R = \frac{(1-r_R)(\phi+\sigma)+Bc}{2(1-r_R)B}, \tag{14}$$

while her choice of Q_{MIN} must satisfy:

$$Q_{MIN} > \phi - \sigma - \frac{(1-r_R)(\phi+\sigma)+Bc}{2(1-r_R)} \tag{15}$$

For the project to be viable under these conditions, it is only necessary that it is profitable in the high-demand state, which occurs when:

$$\phi \geq \underline{\phi}_R^H \equiv \frac{Bc - \sigma(1-r_R) + 2\sqrt{(1-r_R)FB}}{1-r_R} \tag{16}$$

Finally, the project is then viable using rewards-based crowdfunding if it is larger than at least one of the thresholds:

$$\phi \geq \underline{\phi}_R \equiv min\{\underline{\phi}_R^A, \underline{\phi}_R^H\} \tag{17}$$

3.2.1 Optimal Rewards-Based Crowdfunding

Given the entrepreneur's two possible pricing and minimum-quantity decisions, the next step is to characterize the optimal choice between them.

Proposition 1 (Reward-Based Crowdfunding and Project Failure) *It is never optimal for the entrepreneur to set $Q_{MIN} \leq Q(-\sigma)$ if she is unable to earn a profit in the low-demand state ($\pi_R(-\sigma) < 0$). If $\pi_R(-\sigma) < 0$ the entrepreneur will always optimally set $Q_{MIN} > Q(-\sigma)$.*

The first result of this paper concerns the use of the minimum funding goal. The entrepreneur will never optimally allow a project to be funded and then fail in the low-demand state. Instead, if the project is unprofitable when demand is low, the entrepreneur always uses the minimum funding goal to return funds to consumers. This decision prevents consumers from discounting their willingness to pay and increases profits to the entrepreneur when demand is high.

Proposition 2 (Breakdown Without a Binding Minimum Goal) *If the entrepreneur is unable to earn a profit in the low-demand state ($\pi_R(-\sigma) < 0$) there exists a threshold value $\underline{p}_R$ such that for all $p < \underline{p}_R$ the entrepreneur must set a minimum value that excludes the low-demand state $Q_{MIN} > Q(-\sigma)$ to earn a profit in the high-demand state. Otherwise, the project is no longer feasible in either state.*

Proposition 2 presents an alternative case to Proposition 1 and represents the limitations of rewards-based crowdfunding without a binding minimum goal. It demonstrates the consequence to the entrepreneur were she to take the out-of-equilibrium decision to allow the project to proceed in both states if it is unprofitable to produce when demand is low. In this case, consumers discount their willingness to pay and, for highly risky projects, this discounting can be so great as to render the high-demand state unprofitable. However, the entrepreneur can prevent this breakdown by setting $Q_{MIN} > Q(-\sigma)$ and always does so in equilibrium.

This result differs from that of Cumming et al. (2020), in which crowdfunding presents a risk to entrepreneurs rather than consumers. In that paper, crowdfunding without a minimum funding goal is presented as an option with both a lower expected return and lower risk to the entrepreneur, while the model in this paper suggests that consumers actually bear a higher risk when entrepreneurs do not set this minimum goal.

Proposition 3 (Crowdfunding, Profitability, and Minimum Goals) *(i) The threshold for crowdfunding only in the high-demand state is less than or equal to the threshold for crowdfunding in both states ($\underline{\phi}_R^H \leq \underline{\phi}_R^A$).*
(ii) There exists an equilibrium value $\underline{\phi}_{R,Qmin}$ such that for all $\phi \geq \underline{\phi}_{R,Qmin}$, the entrepreneur optimally sets a minimum revenue goal to produce in all states. This value is greater than the zero-profit value for rewards-based crowdfunding in both states $\underline{\phi}_{R,Qmin} \geq \underline{\phi}_R^A$,

Proposition 3 illustrates the entrepreneur's use of a minimum funding goal to remove unprofitable states. For large projects, the entrepreneur is able to make a profit in both states. In this case, the use of a minimum revenue goal by the entrepreneur is irrelevant, as she will always surpass it. She optimally chooses any Q_{MIN} such that she exceeds it in both states.

In other cases, it may not be most profitable for the entrepreneur to set a price considering both possible demand schedules. Specifically, she may set a minimum funding goal (Q_{MIN}) such that she will only receive funding in the case of high demand. There are two cases for using the goal in this way. When projects are very small $\phi \leq \underline{\phi}_R^A$, the low-demand state is simply unprofitable. If the entrepreneur did not exclude these states, she would have to compensate consumers for a positive probability that her project failed. When projects are somewhat larger $\underline{\phi}_R^A \leq \phi < \underline{\phi}_{R,Qmin}$ the situation is more nuanced. If the entrepreneur chooses to produce only in the high-demand state, she can increase her profitability when that state actually realizes through improved price setting that ignores the low-demand state. This new price would earn negative profits if demand were low, and thus the entrepreneur optimally excludes such an outcome.

Corollary 1 (Crowdfunding and Risk) *(i) The threshold project size for crowdfunding, $\underline{\phi}_R$, is independent of the probability of the high-demand state, p.*
(ii) The threshold project size for crowdfunding, $\underline{\phi}_R$, is decreasing in the size of demand risk, σ.

Corollary 1 illustrates the strength of rewards-based crowdfunding technology as it relates to demand-side risk. When the probability of the high-demand state (p) falls, projects are less likely to succeed. However, with crowdfunding this does not increase the minimum viable project size. Entrepreneurs are able to use crowdfunding for projects that, ex-ante, have a very low probability of success.

When the size of risk (σ) increases, projects have a wider variance in their possible outcomes. When this risk increases, the minimum viable project size falls, making more projects viable. This is because as risk increases, entrepreneurs earn higher profits in the high-demand state and larger losses in the low-demand state. With crowdfunding, if the project is unprofitable, entrepreneurs can set a minimum funding goal such that funds are returned and the entrepreneur and consumers earn zero profit rather than taking a loss. Thus, in equilibrium, the entrepreneur can choose to only allow the upside risk of the project to actually realize.

3.3 Equity-Based Crowdfunding Problem

The solution to the entrepreneur's equity-based crowdfunding problem has features similar to both her banking problem and to her rewards-based crowdfunding problem. As with her banking problem, she is able to set a different price for each demand state. As with her rewards-based crowdfunding problem, she is able to remove unprofitable states using her minimum fundraising goal. Her additional complication is that consumers must be willing to invest a sufficient amount to fund her project.

First, consider whether sufficient funds are available. The entrepreneur must receive at least $I_E(\epsilon) \geq F$ for the project to be funded. If the entrepreneur wishes to fund the project in the high-demand state only, this requires $\mu \geq \frac{F}{\phi+\sigma}$. Alternatively, if the entrepreneur wishes to fund the project in both states, she requires a higher value $\mu \geq \frac{F}{\phi-\sigma}$. For projects with a higher level of demand risk (σ) relative to the base size of the project (ϕ), a higher proportion of consumers must be willing to invest in the project for equity crowdfunding to be feasible in all states. The reverse is true if the entrepreneur only wishes to fund the project when demand is high. For expositional simplicity, the remainder of this section assumes that the second condition holds, unless stated otherwise.

Since the entrepreneur sets a price in each state, she can do so regardless of her intention to fund in all states or only the high-demand state. The optimal price in each state is given by:

$$P_E^*(\epsilon) = \frac{\phi + \epsilon + Bc}{2B}, \tag{18}$$

which is identical to the optimal price she sets under banking.

Next, consider an entrepreneur who wishes to receive funds in all states. She sets I_{MIN} such that $I_E(-\sigma) \geq I_{MIN}$. As with rewards-based crowdfunding, there are two possibilities for the entrepreneur when she sets a goal to receive funds in all states: she may be able to produce profitably in both states or only in the high-demand state. As before, the latter case can be ruled out in equilibrium, and the entrepreneur never selects I_{MIN} such that $I_E(-\sigma) \geq I_{MIN}$ if the project is unprofitable with low demand ($\pi_E(-\sigma) < 0$).

For the project to be viable in both states, it must satisfy two conditions. First, the entrepreneur must earn at least zero profit in the low-demand state, and second, the entrepreneur must be able to offer the investing consumers a proportion of the project $\chi \leq 1$. Thus, the project must be viable in both states, which occurs when

$$\phi \geq \underline{\phi}_E^A \equiv min\{Bc + \sigma, Bc + \sigma - 2p\sigma + 2\sqrt{(p^2 - p)\sigma^2 + (1 + r_E)FB}\} \tag{19}$$

The first condition ($Bc + \sigma$) is a result of the entrepreneur's zero-profit condition in the low-demand state, while the second ($Bc + \sigma - 2p\sigma + 2\sqrt{(p^2 - p)\sigma^2 + (1 + r_E)FB}$) is the result of the entrepreneur's equity constraint.

Alternatively, the entrepreneur may set I_{MIN} such that $I_E(-\sigma) < I_{MIN}$, and she only receives funds and produces when demand is high. As before, she is able to do so if she can profitably produce when demand is high and if she can set a $\chi < 1$, which occurs when

$$\phi \geq \underline{\phi}_E^H \equiv min\{Bc - \sigma, Bc - \sigma + 2\sqrt{(1 + r_E)FB}\} \tag{20}$$

Similar to when the entrepreneur funds in all states, the first condition ($Bc - \sigma$) is a result of the entrepreneur's zero-profit condition, while the second ($Bc - \sigma + 2\sqrt{(1 + r_E)FB}$) is the result of the entrepreneur's constraint on giving away less than 100% of the project's equity, such that $\chi \leq 1$.

Finally, the project is then viable using equity-based crowdfunding if it is larger than at least one of the thresholds:

$$\phi \geq \underline{\phi}_E \equiv min\{\underline{\phi}_E^A, \underline{\phi}_E^H\} \tag{21}$$

3.3.1 Optimal Equity-Based Crowdfunding

The optimal use of equity-based crowdfunding has many similarities with the optimal use of rewards-based crowdfunding. For simplicity, this section will focus on elements that are unique to the equity-based crowdfunding decisions.

Corollary 2 (Limiting Factors in Equity-Based Crowdfunding) *For equity-based crowdfunding projects, as ϕ becomes smaller, the entrepreneur's inability to offer more equity to consumers ($\chi \leq 1$) binds before the project's zero-profit condition.*

The first difference between equity-based and rewards-based crowdfunding is the factor that binds the minimum project size ($\underline{\phi}_E$), illustrated in Corollary 2. With rewards-based crowdfunding, the project is viable if the project is profitable in at least one state of the world. The same is not true with equity-based crowdfunding. The limiting factor in equity-based crowdfunding is the need for consumers to earn at least a return of $(1 + r_E)$ on their investment. For some projects to be viable, the entrepreneur would have to offer over 100% of the project's equity return. As a result, projects that would be profitable in at least one state may not always be viable using equity-based crowdfunding.

Proposition 4 (Minimum Investment Goals) *There exists an equilibrium value $\underline{\phi}_{E,Imin}$ such that for $\phi \geq \underline{\phi}_{E,Imin}$ the entrepreneur optimally sets a minimum investment goal such that she produces in all states. This threshold is greater the value of ϕ required for equity-based crowdfunding to earn at least zero profit in both states $\underline{\phi}_{E,Imin} \geq \underline{\phi}_E^A$.*

Proposition 4 is similar in nature to Proposition 3. As with rewards-based crowdfunding, there exists a group of projects that are viable in both states but that the entrepreneur chooses to fund only in the high-demand state. However, the reason is different than with rewards-based crowdfunding. With rewards-based crowdfunding, entrepreneurs may choose to limit viable projects to one state in order to increase profits in the high-demand state through improved price setting. With equity-based crowdfunding, they limit viable projects in order to decrease the equity share they must offer consumers. This is because, with equity-based crowdfunding, entrepreneurs are able to set prices independently in each state, limiting one of the weaknesses of rewards-based crowdfunding.

3.4 Funding Selection Problem

The final stage of the entrepreneur's problem is to select her method of funding given her expected profits in the banking problem, π_B^*, the rewards-based crowdfunding problem, π_R^*, and the equity-based crowdfunding problem, π_E^*.

Proposition 5 (Selection Decision for Large Projects) *There exists a threshold $\overline{\phi}_B$ such that the entrepreneur will always select banking over both rewards-based and equity-based crowdfunding if $\phi \geq \overline{\phi}_B$.*

For projects over a certain size ($\phi \geq \overline{\phi}_B$), entrepreneurs strictly prefer banking over both crowdfunding technologies. While the crowdfunding technologies offer the entrepreneur substantial benefits in the case of projects with unprofitable states, it has no significant benefits for large projects in this model.[10]

The reverse is not necessarily true for smaller values of ϕ since, for some parametrizations with low values of risk, banking may continue to perform well for small projects. However, one key strength of crowdfunding technologies is that they are able to perform well with projects that may be profitable in only one state. Inspection of the minimum thresholds for rewards-based and equity-based crowdfunding ($\underline{\phi}_R$, $\underline{\phi}_E$) show them to be independent of the probability of a high-demand state (p) and decreasing in risk (σ). The same is not true for

[10] Outside this model, crowdfunding may offer entrepreneurs benefits such as significantly more visibility due to a centralized platform.

banking. The threshold for banking is either (1) increasing in risk (σ) or (2) decreasing in risk but also in the probability of a high-demand state (p). Thus, projects with a high level of demand risk or with a low probability of a high-demand state are likely to benefit from both crowdfunding technologies over banking.

Proposition 6 (Selection Decision Crowdfunding Projects) *Equity-based crowdfunding has a lower minimum viable project size than rewards-based crowdfunding ($\underline{\phi}_E \leq \underline{\phi}_R$) unless either (1) the fraction of consumers willing to invest in equity is sufficiently low such that $\mu < \underline{\mu}$; or (2) the required return on equity is sufficiently larger than the rewards-based crowdfunding fee such that $(1 - r_R)(1 + r_E) > 1$, and the marginal cost of production is sufficiently low such that $c < \underline{c}$.*

Proposition 6 illustrates that considerations between the crowdfunding technologies are somewhat different than those involving banking. For equity-based crowdfunding to be viable, there must first be a sufficiently large mass of consumers willing to invest (μ). If this mass is too small, rewards-based crowdfunding will be the only viable option of crowdfunding for small projects. If there are sufficient consumers willing to invest, the trade-off is based on both the relative costs of the two technologies and the entrepreneur's marginal cost of production. The cost of rewards-based crowdfunding must be sufficiently lower than the cost of equity-based crowdfunding such that $(1 - r_C)(1 + r_E) \geq 1$, and the marginal cost of production (c) must be relatively small. Taken together, these two conditions suggest that entrepreneurs can adopt smaller projects for rewards-based crowdfunding when consumer investment demand is low and in industries where marginal costs are low relative to fixed costs (e.g., films and video games).

4 Extension: Crowdfunding with Production Shocks

Thus far, this paper has shown that rewards-based and equity-based crowdfunding are well positioned to help entrepreneurs mitigate risk on the demand side of new projects. In this section, I present an extension in which entrepreneurs face a shock to their production ability rather than consumer demand. This production shock follows the same distribution as their demand shock, but instead either increases or decreases their marginal cost of production such that each unit costs $c - \epsilon$. As before, this shock becomes known once the entrepreneur has paid her fixed costs.

The entrepreneur's banking, rewards-based crowdfunding, and equity-based crowdfunding problems are all solved in similar manners to the baseline model. The main difference is that the minimum revenue (Q_{MIN}) and minimum funding (I_{MIN}) goals no longer protect the entrepreneurs from unprofitable states.[11] In this model, a signal of consumer demand does not provide a signal regarding costs.

As in the base model, there exists thresholds $\underline{\phi}_R$ and $\underline{\phi}_E$ such that all entrepreneurs with $\phi \geq \underline{\phi}_R$ and $\phi \geq \underline{\phi}_E$ are able to profitably engage in rewards-based and equity-based crowdfunding, respectively. However, unlike the base model, crowdfunding has a much more limited applicability. In the base model, projects with at least one profitable state are able to crowdfund. However, since entrepreneurs are unable to screen by production cost, they are unable to isolate a single cost state. Crowdfunding is only feasible if the entrepreneurs are able to set a profitable price across both productions states.

Proposition 7 (Crowdfunding Feasibility with Production Shocks) *When there are shocks to production costs, rewards-based crowdfunding and equity-based crowdfunding no longer have zero-profit thresholds $\phi \geq \underline{\phi}_R$ and $\phi \geq \underline{\phi}_E$ that are independent of the state probability (p).*

Proposition 7 formalizes the weaknesses of rewards-based and equity-based crowdfunding technologies in mitigating uncertainty from the production process. If the entrepreneur were able to isolate states on the production side, as she is able to do on the demand side, she would be able to remove the risk to her customers. For rewards-based crowdfunding,

[11] In an alternative model, where entrepreneurs face both a demand and a supply shock, minimum goals could protect from demand uncertainty, but the entrepreneur would still face difficulty with supply shocks.

consumers now discount their willingness to pay if they will not receive the product in the high-cost state. For equity-based crowdfunding, consumers demand a larger fraction of the project's equity to compensate for losses they incur when costs are high.

The magnitude of risk on the production side also has an inverse result compared to risk on the demand side. Increasing the probability of the high-cost state increases the minimum viable project size, while increasing the size of production-cost risk no longer monotonically reduces the minimum viable project size. Thus, whereas crowdfunding is able to benefit from demand risk, the same is not true for production risk.

A simple interpretation of this result is that if consumers believe that with some probability the cost of production will be higher than the entrepreneur initially believes, the entrepreneur must compensate them appropriately. The result is a decrease in revenue for the entrepreneur and a reduction in the total set of projects she is able to feasibly produce. This result suggests that an important factor for crowdfunders is the demonstration of production ability to consumers. If they are able to credibly demonstrate their production ability to consumers (and themselves), the crowdfunding technology does not face these new weaknesses.

5 Discussion

While crowdfunding has become a much more popular means of achieving early-stage funding for projects, many large projects move to more traditional methods of funding for subsequent cash provision. A prime example is the Oculus Rift headset, which began with a crowdfunding campaign totalling almost $2.5M from over 9,500 backers in August 2012.[12] The company later turned to venture capital for an additional $75M in funding and was eventually purchased by Facebook (now Meta) in a deal worth approximately $2B.[13]

[12] The original Kickstarter page can be found here: https://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game/description.

[13] See the Reuters article "Facebook to buy virtual reality goggles maker for $2 billion" at http://www.reuters.com/article/us-facebook-acquisition-idUSBREA2O1WX20140326 for an example of media coverage on the issue.

The model presented in this paper is a single period model of production where entrepreneurs face risk in the form of a demand shock. The main benefit from crowdfunding technology over conventional banking or existing pre-order schemes relies on the uncertainty surrounding these demand shocks. Once this shock is resolved, crowdfunding may only have drawbacks for subsequent rounds of funding.

In the context of this model, consider a project that produces twice. After the first round of production, the entrepreneur is fully aware of her demand curve but must fund a second round of fixed costs. In this second period, entrepreneurs still have the choice between both crowdfunding technologies and banking and are not obliged to use the same method of funding from the first stage.

This modification removes many of the benefits for both forms of crowdfunding, as banks are now certain about their profitability from the project. In the case of rewards-based crowdfunding, fees can be high compared to both business loans and expected equity returns for more mature companies. Further, these fees are charged on revenue rather than costs. In that sense, this model predicts that once uncertainty is resolved, rewards-based crowdfunding is likely no longer optimal for a large number of projects. This prediction is consistent with existing evidence on crowdfunding projects that seek venture funding or angel investment for subsequent production.

Another function of banks, venture capitalists, and other early sources of financing is screening successful projects. This function has been well documented in the existing literature[14] and, while not modeled explicitly in this paper, screening can serve as an alternate friction in the model. In a simple modification, a bank may have access to a perfect yet costly screening technology that enables them to discern the demand shock faced by the entrepreneur prior to extending a loan and paying the fixed costs. In this case, banks may choose to ration credit, not solely based on default risk but also on whether the expected profit from the loan covers the cost of the screening technology.

[14] See Bester (1985) and Manove et al. (2001) for two of many examples.

As in the base model, crowdfunding partially resolves this screening problem by allowing the producers to remove unprofitable states. The cost is that crowdfunders may either be unable to set as precise an optimal price due to the lack of a pre-screening process or may have to offer a higher return on equity issued. For subsequent production, this screening ability is no longer relevant, and the trade-offs are similar to those presented above. Further, as demonstrated in Section 4, crowdfunding technologies are not useful for screening an entrepreneur's production ability.

6 Conclusion

This paper studies crowdfunding and how it enables entrepreneurial projects that are underserved by the traditional financial system. I build on existing models to show that crowdfunding platforms are a viable means of fundraising in the presence of an existing financial system, without philanthropic motives and with or without investment motives from consumers. Further, I demonstrate key differences between rewards-based and equity-based crowdfunding technologies.

Using a model of consumer demand, I show that that crowdfunding has unique advantages over the existing start-up technologies; it allows entrepreneurs to attempt to engage in projects if only a single state is profitable. This is especially valuable for projects that may have high fixed start-up costs, high variance in demand, or for projects where profitable states are unlikely. In this way, crowdfunding acts as a form of real option. Losses are minimized when demand is low at the cost of reduced profit when demand is high.

For projects of a sufficiently large size, the existing banking system may remain the optimal technology. For rewards-based crowdfunding, this is both because producers are able to adjust their prices after demand has been resolved and because rewards-based crowdfunding platforms typically charge fees based on revenue rather than costs (banking). For equity-based crowdfunding, the required return on equity is likely to be higher than the required interest paid to the bank for large projects, which pay back their loans with certainty.

A weakness of the crowdfunding technology is that, in the case of production cost uncertainty, risk must be passed on to the consumer. In traditional banking, producers are able to set an optimal price, even in the presence of risk. However, when they pass this production risk on to consumers, as is the case with crowdfunding, they must set a price different from the optimal monopoly price. This reduces profitability and leads to a smaller number of feasible projects.

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A List of Variables, Parameters, and Notation

Variable	Description
Constants	
ϵ	realized consumer demand shock
σ	size of consumer demand shock
p	probability consumer demand shock is positive
P	price of consumption good when technology not specified
ϕ	size of consumer demand
B	consumer price sensitivity
F	fixed cost of production for the entrepreneur
c	marginal cost of production for the entrepreneur
r_F	risk-free rate for bank loans
r_R	rewards-based crowdfunding fee
r_E	consumers' required return on equity
μ	fraction of consumers willing to invest in the project
Equilibrium Objects	
$P_B(\epsilon)$	price of consumption good, given ϵ with banking
P_R	price of consumption good with rewards-based crowdfunding
$P_B(\epsilon)$	price of consumption good, given ϵ with equity-based crowdfunding
Q_{MIN}	minimum revenue goal for rewards-based crowdfunding
I_{MIN}	minimum investment goal for equity-based crowdfunding
r_B	expected rate of return for bank loans
χ	equity stake given to the consumers
θ	probability that consumers receive the consumption good if they have paid for it irreversibly prior to production
Functions	
$Q(\epsilon)$	quantity demanded by consumers, given ϵ and price
$I_E(\epsilon)$	investment desire from consumers, given ϵ
π_i	entrepreneur's profit function with technology i

B Appendix: Proofs

B.1 Proof of Proposition 1

Consider the entrepreneur's profit function when she can only earn a profit in the high-demand state ($\pi_R(-\sigma) \leq 0$):

$$\pi_R(\sigma) = p\left((\phi - \sigma - \frac{BP_R}{\theta}) \cdot (P_R \cdot (1 - r_R) - c) - F\right) \tag{B.1}$$

If the entrepreneur sets $Q_{MIN} \leq Q(-\sigma)$ $\theta = p$, while if she sets $Q_{MIN} > Q(-\sigma)$ $\theta = 1$, Equation B.1 is increasing in θ for any P_R s.t. $P_R \cdot (1 - r_R) - c > 0$, which is to say the price net of fees is greater than the marginal cost. Thus, for any price Equation B.1 is greater when $\theta = 1$ and $Q_{MIN} > Q(-\sigma)$ than when $\theta = p$ and $Q_{MIN} \leq Q(-\sigma)$.

B.2 Proof of Proposition 2

Consider an entrepreneur whose project fails when $\epsilon = -\sigma$, but who sets $Q_{MIN} \leq Q_R(-\sigma)$, and therefore $\theta = p$. Manipulation of her maximized profit function shows the project to be profitable in the high-demand state if:

$$\phi \geq \frac{Bc + 2\sqrt{FB(1 - r_R)}}{p(1 - r_R)} + \sigma \tag{B.2}$$

Equivalently, this project is only profitable if:

$$p \geq \underline{p}_R \equiv \frac{Bc + 2\sqrt{FB(1 - r_R)}}{(1 - r_R)(\phi - \sigma)} \tag{B.3}$$

B.3 Proof of Proposition 3

(i) Comparison of the value $\underline{\phi}_R^A$ given by Equation 13 and $\underline{\phi}_R^H$ given by Equation 16 show this to be true.

(ii) The equilibrium expected profit from crowdfunding in both states is given by:

$$\pi_R^A = \frac{((1 - r_R)(p(\phi + \sigma) + (1 - p)(\phi - \sigma)) - Bc)^2}{4B(1 - r_R)} - F \tag{B.4}$$

The same expected profit from crowdfunding only when demand is high is given by:

$$\pi_R^H = \frac{p\left((1 - r_R)(\phi + \sigma) - Bc\right)^2}{4B(1 - r_R)} - pF \tag{B.5}$$

Algebraic manipulation shows that $\pi_R^A \geq \pi_R^H$ when:

$$\phi \geq \frac{Bc + \sigma(1-r_R) + 2\sqrt{(1-r_R)FB + p(1-r_R)^2\sigma^2}}{1-r_R} \tag{B.6}$$

This value is greater than $\underline{\phi}_R^A$ given by Equation 13 as long as $p < 1$.

B.4 Proof of Corollary 1

From Proposition 3, $\underline{\phi}_R^A \geq \underline{\phi}_R^H$ and therefore $\underline{\phi}_R = \underline{\phi}_R^H$. Inspection of $\underline{\phi}_R^H$ shows it to be independent of p and decreasing in σ.

B.5 Proof of Corollary 2

The entrepreneur can earn a profit in the high-demand state if $\phi \geq Bc - \sigma$. Inserting the optimal price into Equation 6 and solving for the consumer's constraint that $\chi \leq 1$ shows that this holds if $\phi \geq Bc - \sigma + 2\sqrt{(1+r_E)FB}$. This condition binds for a greater value of ϕ than the entrepreneur's zero-profit condition above.

B.6 Proof of Proposition 4

This proof follows the same logic as Proposition 3, part (ii). The expected profit for equity-based crowdfunding in both states is:

$$\pi_E^A = \frac{p(\phi+\sigma-Bc)^2 + (1-p)(\phi-\sigma-Bc)^2}{4B} - F(1+r_E) \tag{B.7}$$

The expected profit from equity-based crowdfunding only when demand is high is given by:

$$\pi_E^H = \frac{p(\phi+\sigma-Bc)^2}{4B} - pF(1+r_E) \tag{B.8}$$

Algebraic manipulation shows that $\pi_E^A \geq \pi_E^H$ when:

$$\phi \geq \sigma + Bc + 2\sqrt{(1+r_E)FB} \tag{B.9}$$

This value is greater than either value of $\underline{\phi}_E^A$ given by Equation 13.

B.7 Proof of Proposition 5

The expected profit from banking in both states is given by:

$$\pi_E^A = \frac{p(\phi+\sigma-Bc)^2 + (1-p)(\phi-\sigma-Bc)^2}{4B} - F(1+r_F) \tag{B.10}$$

From Propositions 3 and 4, it is optimal to rewards-based crowdfunding and equity-based crowdfunding in both states for a sufficiently high value of ϕ. Comparing Equations B.10

and B.7, it is always optimal to bank, rather than equity-based crowdfund in these states as long as $r_F < r_E$. Inspection of Equations B.10 and B.4 reveals that it is always optimal to bank, rather than rewards-based crowdfund, in these states if ϕ is sufficiently high.

B.8 Proof of Proposition 6

To raise equity in the high-demand state, the entrepreneur must have a value of $\phi \geq \frac{F}{\mu} - \sigma$. Comparing this value to $\underline{\phi}_R$ shows that $\underline{\phi}_R$ is the strictly lesser of the two when:

$$\mu < \underline{\mu} \equiv \frac{F}{Bc + 2\sqrt{(1 - r_R)FB}} \tag{B.11}$$

If $\mu \geq \underline{\mu}$, the comparison is between $\underline{\phi}_R$ and $\underline{\phi}_E$. Algebraic manipulation of the two values indicates that $\underline{\phi}_R < \underline{\phi}_E$ when:

$$c < \underline{c} \equiv \frac{2\sqrt{(1 - r_R)BF}(\sqrt{(1 - r_R)(1 + r_E)} - 1)}{r_R B}, \tag{B.12}$$

which can only take a positive value if $(1 - r_R)(1 + r_E) > 1$.

B.9 Proof of Proposition 7

For rewards-based crowdfunding consider two strategies. First, consider a project that fails when production costs are high ($\theta = p$). Solving for the expected profit reveals that this project can proceed if:

$$\phi \geq \frac{B(c - \sigma) + 2\sqrt{(1 - r_R)FB}}{(1 - r_R)p}, \tag{B.13}$$

which is decreasing in p. Instead, consider an entrepreneur who sets a price such that she earns at least zero profit in the high-cost state, ignoring the low-cost state entirely. She can set a price that solves this zero-profit condition if:

$$\phi \geq \frac{B(c + \sigma) + 2\sqrt{(1 - r_R)FB}}{(1 - r_R)} \tag{B.14}$$

For p sufficiently high, Equation B.13 is less than Equation B.14, and vice versa. Thus, the threshold is not independent of p.

For equity-based crowdfunding, consider a project that fails when production costs are high. She must be able to both earn a profit in the low-cost state and offer consumers a portion of her project $\chi \leq 1$. Solving the entrepreneur's expected profit, she is able to earn a profit in the low-cost state if:

$$\phi \geq B(c - \sigma) \tag{B.15}$$

She is able to offer consumers a value of $\chi \leq 1$, which solves their zero-profit condition if:

$$\frac{2\sqrt{pBF(1 + r_E)}}{p} + B(c - \sigma) \tag{B.16}$$

The latter condition is strictly greater than the former, decreasing in p, and approaches infinity as p approaches 0. Thus, the threshold is not independent of p.