Does crowdfunding benefit entrepreneurs and venture capital investors?∗

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Abstract

We study how a new form of entrepreneurial finance—crowdfunding—interacts with more traditional financing sources, such as venture capital (VC) and bank financing. We model a multi-stage bargaining game, with a moral-hazard problem between entrepreneurs and banks, and a double-sided moral-hazard problem between entrepreneurs and VCs. We decompose the economic value of crowdfunding into cash gains or losses, costs of bad investments avoided, and project-payoff probability update. This economic value is generally shared between entrepreneurs and VC investors, benefiting both. In addition, crowdfunding can alleviate the under-investment problem due to moral-hazard frictions. Furthermore, crowdfunding allows some projects to gain access to both VC and bank financing and the competition between those investor classes benefits entrepreneurs. However, competition from other investors reduces value to VC investors, who may walk away from the deal entirely. This can also hurt entrepreneurs who lose out on valuable VC expertise.

Key words: Crowdfunding, Entrepreneurship, Venture Capital, Operations and Finance Interface, Double-sided Moral Hazard, Bargaining Games

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1 Introduction

How should early-stage startups be financed? Traditionally, entrepreneurs with innovative ideas in need of financing have relied on supply of capital from banks, venture capital investors (VCs), and other sources (Chemmanur and Fulghieri 2014). Over the past decade, crowdfunding has emerged as an additional source of financing for early-stage startups. The growth of the crowdfunding industry has been remarkable. By 2015, crowdfunding accounted for $2.7 billion of financing for early-stage ventures in the US (Massolution.com Industry Report, 2015). In the UK, the amount of financing raised through “alternative financial markets”, which includes crowdfunding, went up from $309 million in 2011 to $939 million in 2013 (Collins et al., 2013).

Such growth has inspired multiple studies of crowdfunding. The majority of them focus on predicting crowdfunding campaign outcomes and on the optimal campaign design (see the detailed discussion in §2). However, the broader questions of how crowdfunding alters entrepreneurs’ financing preferences and how crowdfunding platforms fit in with the traditional startup financing sources, such as banks and VCs, have received relatively little attention. In this paper, we explore this issue. Specifically, we answer several important questions: how does the presence of a crowdfunding platform change the strategic interactions and the financing decisions of entrepreneurs, banks and VCs? What types of projects should be financed via this new platform? What are the benefits and costs to the entrepreneurs and investors from having crowdfunding in the economy?

To understand the role of crowdfunding in the cycle of entrepreneurial financing, it is useful to discuss briefly how crowdfunding works and review an example. Crowdfunding platforms connect entrepreneurs with a crowd of potential customers, who are typically promised a finished product, once it becomes available (or other rewards). The entrepreneur puts together and runs a campaign. This usually involves designing a webpage, preparing marketing material to promote the product, and interacting with potential backers. Campaigns consume entrepreneurs’ time and resources, which one can abstractly interpret as upfront cost. A campaign has a duration and a funding goal. On many platforms such as Kickstarter, crowdfunding leads to binary outcomes: success or failure. The campaign is a success if the funding goal has been met. In this case the entrepreneur can access the raised funds. The campaign is a failure if the funding goal is not met. In this case the backers receive their pledges back and the project is typically scrapped.

As an example, consider the Kickstarter campaign for C.H.I.P., “the world’s first $9 computer.”1 The campaign launched in May 2015 with a goal of $50,000. When it closed a month later, they had raised more than $2 million from almost 40,000 backers. What is the significance of these numbers?

One of the benefits of crowdfunding is raising money. However, despite the existence of some extremely well-funded projects, successful crowdfunding campaigns typically raise too little to cover all of the project’s financing needs and crowdfunding does not act as a direct competitor for traditional sources like VCs and banks. To this point, venture capital accounted for $58.8 billion invested in 2015, as opposed to $2.7 billion in reward-based crowdfunding. Bank loans provide four

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1https://www.kickstarter.com/projects/1598272670/chip-the-worlds-first-9-computer
times as much entrepreneurial financing as VC investments (Berger and Udell 1998).

The other benefit of crowdfunding is providing information about potential demand for the product. In 2014, *Bunch O Balloons* campaign on Kickstarter raised nearly $1m. As Josh Malone, the company’s founder, observed (Groom 2017): “The funds were helpful but passing the test of marketability had huge implications. All of a sudden retailers wanted to secure the product.” Importantly, crowdfunding information is public. The success or failure of a campaign is visible to traditional investors. As such, crowdfunding outcomes serve as a credible public signal of firm prospects, and affect the perception of the project-payoff probability. As explained by Judd Hollas, the CEO of crowdfunding platform EquityNet: “if a crowdfunding campaign generates a lot of interest in a product, it’s a signal to a VC firm that a company may be worth investing in” (EquityNet, 2014).

Consider *Oculus Rift*, the virtual reality visor which was launched on Kickstarter in 2012. The firm raised $2.4 million through crowdfunding, almost 10 times its original target. This success generated a lot of interest and culminated in a sizable $75 million investment from Andreessen Horowitz VC. Brendan Iribe, the CEO, commented that “this additional infusion of capital, as well as the leadership and experience of Marc Andreessen, will help us take the final steps toward our ultimate goal: making virtual reality something consumers everywhere can enjoy” (Bradshaw, 2013). In the case of *Oculus Rift*, the combination of crowdfunding success and VC involvement turned this startup, seeking to raise $250 thousand on Kickstarter in 2012, into a $2 billion company acquired by Facebook just 2 years later, providing VCs with a handsome payoff on their investment.

Our study analyzes the two channels by which crowdfunding can affect financing decisions and outcomes: cash and information. *Oculus Rift* is just one of many examples that highlight the complementarity of crowdfunding to other forms of early stage financing. By raising funds and providing an early signal of public interest, crowdfunding enables access to additional funding from traditional investors, improving outcomes for everyone. At the same time, the public nature of the signal may not always be desirable. Beyond the obvious case in which crowdfunding publicly reveals that the entrepreneur’s idea is a failure, there can be more subtle implications. For instance, if the campaign is too successful, there may not be enough upside left for VCs, who typically prefer getting in early to secure a big share of the pie. In fact, recent empirical evidence from Ryu and Kim (2017) suggests that successfully crowdfunded projects may lose out on subsequent financing. Anticipating losing projects to other investors after a campaign, VCs may choose to increase their contributions and forgo crowdfunding. For example, company *612 games* was set to launch a $250,000 campaign on Kickstarter in 2017. But following a positive reveal event, the company received additional funds from its current investors and canceled crowdfunding plans (Donnelly 2017).

To explore these trade-offs rigorously, we model a multi-stage game between an entrepreneur, VCs, and a competitive banking industry. The game features double-sided moral hazard, in that both the entrepreneur and VCs can exert effort to improve the outcome of the project, but such effort is non-observable and non-contractible. Banks only provide funds. Entrepreneurs can seek financing from banks and bargain with VCs, but also have the option of crowdfunding, if the
negotiations with traditional investors fail. Consistent with practice, the crowdfunding outcome is public knowledge, and once it is revealed, the entrepreneur can again try to negotiate financing with banks and VCs. Crowdfunding changes the pledgeable capital of the entrepreneur and public beliefs about the project-payoff probability. To study crowdfunding value and its effect on equilibrium decisions, we compare two economies (with and without crowdfunding).

Based on this analysis, we divide the economic value of crowdfunding into the expected cash gains, costs of bad investments avoided, and project-payoff probability updates. This value is generally shared between the entrepreneur and VCs, benefiting both. Furthermore, crowdfunding can benefit entrepreneurs and investors by providing access to financing for good projects that would not be financed otherwise. In particular, crowdfunding can alleviate the under-investment problem due to moral hazard frictions. In addition, for some projects, crowdfunding enables access to both VC and bank financing, and competition between those investors benefits the entrepreneur.

However, we also find that crowdfunding, even when it is successful, may erode values of VCs and sometimes even of the entrepreneur. We show that having too much capital or having a project whose a priori payoff probability is very high may reduce the VCs’ incentives to exert effort, which can undermine negotiations between VCs and the entrepreneur. Moreover, we show that competition from bank investors reduces the value captured by the VC investors, sometimes to the degree that VCs walk away from the deal entirely. VCs’ effort is valuable and if the entrepreneur cannot overcome moral hazard frictions, then the entrepreneur’s value is reduced as well. Unfortunately, the essential feature of crowdfunding—its public nature—makes it difficult to overcome moral hazard friction for some projects, because the entrepreneur cannot strategically hide wealth or the success probability of the project, after the outcome of the campaign is revealed.

2 Literature review

To the best of our knowledge, this is the first paper to study the interactions between crowdfunding, banks, and venture capital investors, in a multi-period setting, with competition between investor classes. Our paper draws from several literature streams, spanning different fields.

We use moral hazard as the cause of financial frictions in our paper. The main idea is that the insiders of the firm (in this case, the entrepreneur) can influence the value of the investment by exerting unobservable effort, which is costly. The outside investors (e.g., bank investors) may be unwilling to provide financing if they are not sure whether the entrepreneur will exert the necessary effort. This approach follows in the footsteps of numerous papers in finance, particularly the seminal works by Jensen and Meckling (1976) and Myers (1977). The textbook by Tirole (2010) provides an excellent introduction into this literature. Recently, several papers in the OM/Finance interface have adopted similar models for financial frictions, e.g., Chod (2015) and Ning and Babich (2016).

We treat bank investors and VC investors differently. Regular bank investors simply provide capital and are in perfect competition with each other. However, VCs provide more than just capital: they offer management skills, experience, connections, etc. Hellmann and Puri (2002) and
Aggarwal et al. (2015) provide empirical support for this argument. The extra value that VCs provide requires effort, which is also unobservable and costly. Therefore, we employ the double-sided moral hazard framework. VC investors have bargaining power and to describe the outcome of negotiations between the entrepreneur and VC investors we rely on the bargaining games introduced and developed by Nash (1950), Nash (1953) and Binmore et al. (1986).

Prior studies applied moral hazard and bargaining to model the interactions between entrepreneurs, banks, and VCs. Casamatta and Haritchabalet (2014) consider the entrepreneur’s choice of committing to exclusive VC relationships vs. working with multiple VCs. They characterize the conditions under which each strategy is optimal. Chemmanur and Chen (2014) analyze the entrepreneur’s choice between VC and angel financing in a multi-stage setting, with double-sided moral hazard. Renucci (2014) studies a double-sided moral hazard model in which entrepreneurs can strategically hide their wealth if needed, but does not consider crowdfunding. He finds that access to bank financing can preclude access to VC under certain conditions. Our single-stage model is similar to that in Renucci (2014). However, we extend the analysis beyond the single-stage and capture interactions between the entrepreneur, VCs, and bank investors in a multi-stage game, where access to bank financing is enabled by crowdfunding. The essential feature of crowdfunding is the public signal it sends to the investors. Therefore, unlike Renucci (2014)’s model, in our model the entrepreneur may find it difficult to hide her wealth and her project’s prospects.

Crowdfunding is a recent phenomenon and, therefore, literature on crowdfunding is still relatively small. However, there is empirical support for some of the predictions of this paper. For example, as mentioned earlier, Ryu and Kim (2017) show that projects that experience a positive crowdfunding outcome may sometimes lose access to VC financing ex post. Colombo and Shafi (2016) find empirical evidence that successful crowdfunding can either facilitate or hinder VC financing ex post. Drover et al. (2015) conduct a lab experiment and show that crowdfunding can act as a certification, making it easier for firms to obtain financing ex post. These papers provide evidence supporting our premise that crowdfunding can alter financing outcomes. Our paper complements these empirical papers by providing a theoretical framework to explain “why” and “how” this can happen.

Most of the crowdfunding research focuses on the campaign design questions and on predicting campaign outcomes. For example, Agrawal et al. (2011) study the impact of geographic proximity on backers’ pledging behavior. Mollick (2014) analyzes data pertaining to over 48,000 projects launched on Kickstarter and finds evidence that certain project characteristics (e.g. the campaign has a video) are highly correlated to the success of the campaign. Li and Duan (2016) focus on the effect of network externalities and deadlines, while Kuppuswamy and Bayus (2015) establish a U-shape funding pattern that emerges consistently across different categories. Chakraborty and Swinney (2016) study a signaling game in which quality is privately observed by the entrepreneur, and focus on the question of how quality can be signaled to potential contributors through the campaign design. Alaei et al. (2016) use a dynamic model to study the implications of backers’ pledging behavior over time, and understand how the informational cascades that ensue can affect the probability of success of a project. Chen et al. (2017) study how to set the parameters of a
crowdfunding campaign when taking into account the possibility of venture capital funding. Hu et al. (2015) investigate the interaction between product line decisions, customers’ valuation heterogeneity, and the design of a crowdfunding campaign, and find that product lines are less heterogeneous in quality when offered via crowdfunding compared to more traditional strategies. For a recent review of crowdfunding papers see Moritz and Block (2016). Compared with these papers, we adopt a more strategic perspective and study the fit of crowdfunding with traditional financing choices.

Lastly, this paper is related to work at the interface of operations and finance. Early papers include Babich and Sobel (2004), Buzacott and Zhang (2004), Xu and Birge (2004), and Dada and Hu (2008), who show how financing constraints can affect a firm’s capacity choice. Similarly, Babich (2010), Kouvelis and Zhao (2012), Alan and Gaur (2012), and Birge and Yang (2013) look at issues of supply chain coordination under leverage. We refer the reader to Kouvelis (2012) for a review of this literature. We extend this literature by studying crowdfunding as an additional source of financing for entrepreneurs and its interactions with the traditional financing choices.

3 Model

In this section we first introduce projects and agents in the economy. We discuss how project outcomes depend on agents’ efforts and information. Then, we introduce a simple model of crowdfunding and connect it with the cash flows and information about projects. Finally, we present the full multi-stage contracting and negotiation game between the agents.

3.1 Projects and agents

The economy comprises an entrepreneur, regular investors (which we shall call ‘bank investors’), and venture capital investors (VCs). The entrepreneur has an idea for a project, which requires a total investment $I$. The project pays $R$ with probability $p(e, v, s)$ and 0 with probability $1 - p(e, v, s)$.

The payoff probability $p(e, v, s)$ depends on $e$ and $v$, representing effort levels exerted by the entrepreneur and VC, respectively, and on a public signal $s$, representing information about the project. The VCs’ effort affects $p$ because VCs provide more than just financing for their investments. They connect entrepreneurs with supplier and distribution networks, introduce entrepreneurs to management talent, guide and mentor entrepreneurs through the process of running a company, etc. Efforts are costly, but are not observable or contractible. For simplicity, effort levels are binary, that is, $e \in \{0, B\}$ and $v \in \{0, C\}$ and the cost of effort is the effort amount.

The project’s total expected value is

$$V(e, v, s) \overset{\text{def}}{=} p(e, v, s)R - I - e - v.$$ (1)

To facilitate the subsequent analysis, we shall make the following intuitive assumptions about the effect of efforts on the success probability $p$. For any signal $s$, efforts increase the probability of project success: $p(B, C, s) > p(B, 0, s) > p(0, 0, s)$ and $p(B, C, s) > p(0, C, s) > p(0, 0, s)$.
We assume the separability of each agent’s contribution when exerting effort, that is, the impact of one agent’s effort on the success probability of the project does not depend on the other agent’s effort and on the public signal. Let $\delta_B$ ($\delta_C$) represent the increase in probability realized as a result of the entrepreneur’s (VCs’) providing effort. This implies, for any $e$, $v$, and $s$, that

$$\delta_B = p(B, v, s) - p(0, v, s), \quad \delta_C = p(e, C, s) - p(e, 0, s).$$

(2)

We shall assume that efforts increase overall value, that is

$$\delta_B R - B \geq 0, \quad \delta_C R - C \geq 0.$$

(3)

Although the success probability depends on both efforts, we assume that the entrepreneur’s effort is crucial for the project’s success, i.e., for all $v$ and $s$, the NPV of the project without the entrepreneur’s effort is negative, $V(0, v, s) < 0$.

The public signal $s$ about the project can be low ($-1$), neutral (0), and high (1) with $p(e, v, -1) < p(e, v, 0) < p(e, v, 1)$ for all efforts $e$ and $v$. Neutral signal (0) represents no information about the project. To simplify the analysis, the project is unprofitable if $s = -1$, i.e., $V(e, v, -1) < 0$. For all $s \neq -1$, the project is profitable with efforts, $V(B, C, s) > 0$. This asymmetry between high and low signals simplifies the analysis by removing the need to consider “false negatives.” It does not alter our qualitative insights. It is in line with an analogous assumption in Biais and Gollier (1997).

3.2 Crowdfunding

The entrepreneur has the option of launching a reward-based crowdfunding campaign, pitching her project to consumers. The consumers are not investors, but buyers: they receive a product, but do not have a claim on the project’s payoffs after the campaign is over. Such campaigns are offered on major crowdfunding platforms such as kickstarter.com and indiegogo.com.

Crowdfunding comes at cost $k$, which captures initial expenses related to the campaign, e.g., website development, marketing, fees, etc. If the campaign is successful, it raises a net amount $A > 0$, which includes any nonpecuniary rewards that have been paid or are owed to the crowd. Crowdfunding has two effects.

First, it changes the amount of pledgeable capital of the entrepreneur. Before crowdfunding the entrepreneur has $a$ in liquid assets (“cash”, for short). After a successful crowdfunding campaign, her cash position becomes $A - k + a$. After a failed crowdfunding campaign, her cash position becomes $a - k$. The cost of the campaign is lower than the initial cash, $k \leq a$. To avoid trivial scenarios, $A + (a - k) < I$, so that crowdfunding, on its own, does not suffice to fund the project.

Second, crowdfunding changes the publicly-observed signal about the project. Before crowdfunding, the signal is $s = 0$. A successful campaign changes the signal to $s = 1$. A failed campaign changes the signal to $s = -1$. The usual Bayesian framework applies (prior distribution of the project to be of high or low type, conditional probabilities of a successful or failed campaign given true types, etc.). However, we shall need primarily the unconditional probability that a campaign
succeeds, denoted by $Pr(H)$. Probability $p(e, v, s)$ incorporates updates in beliefs through $s$.

It will be convenient to define the following shorthand notation for probabilities, values (and other quantities), given that signal $s = 1$ is received: $p'(e, v) \equiv p(e, v, 1)$, $V'(e, v) \equiv V(e, v, 1)$. Similarly, we shall use shorthand notation $p(e, v) \equiv p(e, v, 0)$ and $V(e, v) \equiv V(e, v, 0)$, given $s = 0$.

Importantly, the crowdfunding outcome is public. Hence, the entrepreneur cannot strategically hide the resulting success probability of the project or her cash position. This will have implications for the analysis.

### 3.3 Financial markets, frictions, and the negotiation sequence

There are two traditional financing sources: regular investors (aka bank investors) and VCs. The entrepreneur will choose a feasible financing source that is the most profitable to her. Frictions might prevent financing from either source. The interactions between the entrepreneur and bank investors are subject to moral hazard with respect to the entrepreneur’s effort. This is a classical form of frictions studied in the literature (Jensen and Meckling, 1976 and Myers, 1977). The interactions between the entrepreneur and VCs are subject to double-sided moral hazard. This reflects the special role of VCs (Casamatta, 2003 Renucci, 2014 and Chemmanur and Chen, 2014). An advantage of our project payoff model (and this has long been recognized in the literature) is that, in case the project does not pay, the value to be divided among multiple claim holders is zero. Thus, the complex issues of bankruptcy-payment seniority are avoided, which allows us to focus on the main story of financial frictions engendered by moral hazard.

Bank investors are perfectly competitive and are willing to accept any proposal from the entrepreneur that makes them break even. Our model of interactions between the entrepreneur and bank investors is in the spirit of Holmström and Tirole (1997). We describe the details of the contracts and present the solution to the game between the entrepreneur and bank investors in §4.2. In contrast to bank investors, because VCs bring unique value to the project, VCs have bargaining power. We follow the standard literature and model the negotiation between the entrepreneur and the VCs as a Nash bargaining game in the spirit of Rubinstein (1982). The details are in §4.3.

There is no collusion (between investors or between the entrepreneur and one group of investors against the other group). Evidence in support of this assumption can be found in Casamatta and Haritchabalet (2014), who describe potential benefits of maintaining exclusive relationships.

We conclude the model section by describing how the interactions between the entrepreneur and the investors unfold over time and pointing out at what stage crowdfunding can be used. Figure 1 offers a visual guide for this discussion.

At $t = 0$, the entrepreneur has pledgeable capital $a < I$. To raise the financing necessary for investment in the project, the entrepreneur negotiates financing with bank investors and VCs and chooses the financing source that is the most profitable. If financing negotiations are successful, the project is launched, payouts and values are realized, investors are repaid and the game ends. If financing negotiations fail, the game moves to the crowdfunding stage.

At $t = 1$, the entrepreneur has the option to launch a crowdfunding campaign at cost $k < a$. 

Once the outcome of the campaign is revealed, the public signal is updated from $s = 0$ to $s \in \{-1, 1\}$, the entrepreneur’s pledgeable capital changes from $a$ to either $a - k$ or $a - k + A$, and the game moves to the next period.

At $t = 2$, once all agents have observed the crowdfunding outcome, the entrepreneur can (again) negotiate financing with bank investors and VCs. At this time, the only two possible outcomes of the negotiations are either to abandon the project or to invest in the project.

The entrepreneur and the VCs at $t = 0$, anticipate the subsequent decisions to undertake crowdfunding, and negotiations at $t = 2$. In contrast, bank investors are not strategic in the negotiation. There is an infinite supply of bank investors. Therefore, bank investors negotiating with the entrepreneur at $t = 0$ and at $t = 2$ are not necessarily the same investors.

4 Benchmark analyses

In this section we analyze several simpler models, which we shall use as building blocks for the main model and also as benchmarks to understand the role and value of crowdfunding and financing frictions. In §4.1, we assume away financing frictions and derive formulas for the economic value of crowdfunding. In §4.2, we compute a solution of the contracting problem between the entrepreneur and bank investors, in the absence of crowdfunding and VC financing. In §4.3, we compute a solution to the negotiation problem between the entrepreneur and VCs.

4.1 The economic value of crowdfunding

In this subsection we assume away financing frictions, by making all efforts contractible and delegating all decisions to a central planner. This allows us to evaluate the economic value of crowdfunding. For the subsequent analysis we shall need the value of crowdfunding with and without the VCs’ effort. To save space, we derive the value with the VCs’ effort here. By setting the VCs’ effort to $v = 0$, one obtains the other case. The decision tree in Figure 2 helps with the discussion.

In this decision tree, the first decision of the entrepreneur is either to forgo crowdfunding and invest into the project directly (lower branch of the tree) or to start a crowdfunding campaign (upper branch). Following the lower branch, the entrepreneur and the VCs decide whether to exert efforts $e, v$. Then, uncertainty about the project outcome is realized and payment $R$ is received with probability $p(e, v)$ (recall our shorthand notation $p(e, v) = p(e, v, 0)$). Because we assumed that efforts are value enhancing, the optimal choice will be $e = B$ and $v = C$. Thus, the value when
forgoing crowdfunding is $p(B, C)R - I - B - C$.

Alternatively, following the upper branch, the entrepreneur can start a crowdfunding campaign, paying the campaign cost $k$. With probability $Pr(H)$, the campaign is successful, cash $A$ is raised and the positive signal $s = 1$ is recorded. Then the decision to invest $-I$ is made and agents exert efforts $e = B$ and $v = C$ (because efforts are value enhancing). Uncertainty about the project outcome is realized and payment $R$ is received with probability $p'(e, v)$ (recall $p'(e, v) = p(e, v, 1)$). With probability $1 - Pr(H)$, the campaign is not successful, signal $s = -1$ is recorded and the project is abandoned (from the assumption that the project’s value is negative if $s = -1$). Overall, the value along the crowdfunding branch is $Pr(H)A - k + Pr(H)[p'(B, C)R - I - B - C]$.

The economic value of crowdfunding is the difference in values between the upper and lower branches and it equals

$$F(v) = \underbrace{(-k + Pr(H)A)}_{\text{cash flow gains/losses}} + \underbrace{Pr(L)(I + B + v)}_{\text{costs avoided}} + \underbrace{(Pr(H)p'(B, v) - p(B, v))}_{\text{payoff probability update}} R. \quad (4)$$

Three fundamental forces affect the economic value of crowdfunding: the cash flow gains or losses incurred (first term), the costs avoided (second term), and the payoff probability update (third term). Crowdfunding is value increasing in the centralized economy if and only if $F(v) \geq 0$.

While it is natural to assume that the probability update can only be positive, the cash flow gains may be either positive or negative. The net value of crowdfunding may still be positive if the probability update and costs averted are greater than cash flow losses. Next, comparing $F(0)$ and $F(C)$, one can show the following.

**Proposition 1.** The economic values of crowdfunding with and without VCs’ effort are related by $F(C) = F(0) - Pr(L)(\delta_C R - C)$. The economic value of crowdfunding is greater without VCs’ effort, $F(0) \geq F(C)$.

From Proposition 1, assuming the signal does not affect the change in project success probability due to VCs’ effort, the economic value of crowdfunding is lower in the economy with VCs than in the economy without VCs. To keep the analysis interesting, it is natural to assume that
Assumption 1. The economic value of crowdfunding is non-negative: $F(C) \geq 0$.

4.2 Contracting between the entrepreneur and bank investors

In this subsection, we present a framework of bank financing, which will be helpful in the later discussions on the effects of crowdfunding. Our analysis follows the standard model of financing under moral hazard (see Holmström and Tirole, 1997, Tirole, 2010, and Ning and Babich, 2016). We shall assume that only bank financing is available and the VCs’ effort is $v = 0$.

The game between the entrepreneur and bank investors develops as follows. The entrepreneur with pledgeable capital $c$ approaches bank investors with a take-it-or-leave-it proposal to borrow $I - c$ and a promise to repay an amount $r$ in the future, if the project is successful. The entrepreneur can affect success probability, but the costly effort is private. To ensure that the entrepreneur exerts effort, and investors do not lose value financing the project, the contract must satisfy standard incentive compatibility and individual rationality constraints:

$$p(B, 0, s)(R - r) - B \geq p(0, 0, s)(R - r)$$

and

$$p(B, 0, s)r \geq I - c,$$

respectively. These constrain the repayment amount $r$ to

$$(I - c)/p(B, 0, s) \leq r \leq R - B/\delta_B,$$  \hspace{1cm} (5)$$

with $\delta_B = p(B, 0, s) - p(0, 0, s)$ defined in (2). As long as condition (5) is satisfied, bank investors will finance the entrepreneur. This leads to the following Proposition.

Proposition 2. Bank financing is feasible if and only if the project is economically viable, that is $V(B, 0, s) \geq 0$, where $V$ is defined in (1), and

$$V(B, 0, s) \geq 0$$

$$(I - c)/p(B, 0, s) \leq R - B/\delta_B.$$  \hspace{1cm} (BF)$$

This is a known result (Tirole, 2010, Chapter 3), but it is convenient to reproduce it in our notation. Intuitively, bank financing is feasible if, relative to project payoff $R$, the external capital required $L = I - c$ is not too large (equivalently, if the entrepreneur has sufficient “skin in the game,” $c$), the success probability of the project $p(B, 0, s)$ is high, and the informational cost due to moral hazard $B/\delta_B$ is low. Later we shall consider how crowdfunding affects these elements.

Due to perfect competition between bank investors, the entrepreneur can offer the repayment at the lower boundary of the financing feasible region (5). It is convenient to label this quantity as

$$\hat{r}(C, s) = (I - c)/p(B, 0, s).$$  \hspace{1cm} (6)$$

When $r = \hat{r}(c, s)$ the entrepreneur extracts the entire value of the project $V(B, 0, s)$. Thus, under bank financing, the entrepreneur’s share of the value is $S = V(B, 0, s)$.

Next, we shall illustrate bank financing feasibility from Proposition 2 graphically, on Figure 3. On the horizontal axis of this figure, we measure the amount of external capital needed $L = I - c$ to invest in the project. On the vertical axis we measure the probability of a successful outcome $p = p(B, C, s)$ for the project, when both the entrepreneur and VCs’ efforts are contributed. Even though there
are no VCs in the model in this subsection, we use variable $p$ to facilitate the comparisons with later models. From definitions (2), there is a connection between $p$ and $p(B,0,s)$: $p(B,0,s) = p - \delta_C$.

From Proposition 2, projects must be economically viable $V(B,0,s) = p(B,0,s)R - I - B \geq 0$. This is equivalent to condition $p \geq (I + B)/R + \delta_C$. From Proposition 2, projects must satisfy (BF). This is equivalent to condition $p \geq L/(R - B/\delta_B) + \delta_C$. We define line $\ell_1$ as the set of points $(L,p)$, where the latter inequality is binding. Table 4 in Appendix A summarizes definitions of lines.

In the shaded region of Figure 3, bank financing is feasible. In the non-shaded region bank financing is not feasible, even for projects that are economically viable. This illustrates the notorious underinvestment inefficiency due to financial frictions in the form of moral hazard (Holmström and Tirole, 1998). In the following sections, we shall show how crowdfunding may help to reduce the underinvestment inefficiency.

### 4.3 Negotiations between the entrepreneur and the VCs

In this subsection, we analyze a model of negotiations between the entrepreneur and the VCs. In contrast to bank investors, the VCs contribute capital and effort to the project’s success and they also have bargaining power.

We begin with the double-sided moral hazard discussion. The entrepreneur and the VCs invest $c$ and $I - c$, respectively, in the project. The entrepreneur promises to pay VCs $\rho$ in the future, if the project is successful. Efforts of both the entrepreneur and the VCs are not contractible, which creates a double-sided moral hazard problem. To ensure that, in equilibrium, both parties exert efforts, payment $\rho$ must satisfy the following incentive compatibility constraints: $p(B,C,s)(R - \rho) - B \geq p(0,C,s)(R - \rho)$ and $p(B,C,s)\rho - C \geq p(B,0,s)\rho$, for the entrepreneur and the VCs, respectively. These conditions constrain values of the payment amount $\rho$, as follows

$$\frac{C}{\delta_C} \leq \rho \leq R - B/\delta_B,$$

with $\delta_B = p(B,C,s) - p(0,C,s), \delta_C = p(B,C,s) - p(B,0,s)$ defined in (2). Quantities $\frac{B}{\delta_B}$ and $\frac{C}{\delta_C}$ represent moral hazard costs due to the entrepreneur’s and the VCs’ efforts, respectively.
necessary condition for securing financing in equilibrium, where both agents exert efforts, is that the total moral hazard cost does not exceed the payout of the project: $B/\delta_B + C/\delta_C \leq R$. However, this assumption is not sufficient. In addition, the contract must distribute the value from the project between the entrepreneur and the VCs in a way that reflects the negotiation outcome.

To capture the negotiation outcome, we use a simple version of the Nash Bargaining game (Nash, 1950). More sophisticated models (Rubinstein, 1982; Renucci, 2014) can also be used, but our insights will not be altered qualitatively. We connect the equilibrium contract with negotiation outcome in two steps. First, we determine how the agents split the value from the project $V(B, C, s)$, and second, compute the transfer payment $\rho$, which matches this split.

Let’s determine the share ($S_i$, $i \in \{e, v\}$) of value that each agent receives through bargaining. In equilibrium $S^e + S^v = V(B, C, s)$. Let $d^i$ represent agent $i$’s disagreement point, that is, the value of an outside option for that agent in case the negotiations break down, and let $\theta \in (0, 1)$ be the entrepreneur’s inherent bargaining power ($1 - \theta$ is the VCs’ bargaining power). Bargaining power $\theta$ is exogenous, but disagreement points $d^i$ in our model are endogenously determined and they depend on the financing options available to the entrepreneur. The agents’ shares are computed as a solution of the following optimization problem (Nash, 1950):

$$\max_{S^e, S^v} (S^v - d^v)^{1-\theta} (S^e - d^e)^{\theta}$$

subject to $S^e + S^v = V(B, C, s)$. (8b)

The solution to the above problem is

$$S^e = [V(B, C, s) - d^v - d^e] \theta + d^e$$

$$S^v = [V(B, C, s) - d^v - d^e] (1 - \theta) + d^v.$$ (9a, 9b)

Next, we compute the equilibrium transfer payment $\rho$ to match the bargaining outcome (9). The equation for the VCs is $p(B, C, s) \rho - C - (I - c) = S^v$ and it yields an equilibrium transfer payment

$$\hat{\rho}(c, s) = \frac{S^v + C + (I - c)}{p(B, C, s)}.$$

(10)

Combining value sharing solution (10) with the incentive compatibility constraints (7) we derive feasibility conditions for VC financing.

**Proposition 3.** VC financing is feasible if and only if the project is economically viable ($V(B, C, s) \geq 0$), the value of the project exceeds disagreement values ($V(B, C, s) \geq d^e + d^v$), and

$$C/\delta_C \leq \frac{S^v + C + (I - c)}{p(B, C, s)} \leq R - B/\delta_B.$$ (VF)

where $S^v$ is given in (9b).

Proposition 3 is the key takeaway from this subsection. These conditions tie together, for an arbitrary signal $s$, the pledgeable capital of the entrepreneur $c$, moral hazard costs of the entrepreneur
and the VCs, the value of the project when both agents exert effort, the bargaining powers of agents, and the outside options available to each agent. In the subsequent discussion we shall see how crowdfunding affects these elements. In preparation for those sections, it is useful to solve two special cases of the general problem presented in this subsection: a model where there are no alternatives to VC financing and a model where bank financing is an alternative to VC financing.

4.3.1 Equilibrium when there are no alternatives to VC financing

The assumption that there are no alternatives to VC financing translates to applying disagreement values $d^e = d^v = 0$ to equations (9) and Proposition 3. Consequently, we have the following Corollary to Proposition 3.

**Corollary 1.** Suppose $d^e = d^v = 0$. VC financing is feasible if and only if the project is economically viable ($V(B, C, s) \geq 0$) and

$$C/\delta_C \leq \frac{(1-\theta)V(B, C, s) + C + (1-\theta)p(B, C, s)}{R - B/\delta_B}. \quad (11)$$

If VC financing is feasible, then the shares of the entrepreneur and the VCs are $S^e = \theta V(B, C, s)$ and $S^v = (1-\theta) V(B, C, s)$, respectively. If VC financing is not feasible, then the shares are zero.

Figure 4 illustrates financing feasibility conditions in Corollary 1 graphically. We use the same variables $(L, p)$ for axes as we did in Figure 3. Depending on the choice of the parameter values, the feasible region takes different forms, as discussed in Lemma 1 (Appendix) and shown in panels of Figure 4. The economic viability line, $V(B, C, s) = 0$, is $p = (I + B + C)/R$. Line $\ell_2$ corresponds to the first inequality in (11) becoming equality. This inequality controls the VCs’ moral hazard incentives. Line $\ell_3$ corresponds to the second inequality in (11) becoming equality. This inequality controls the entrepreneur’s moral hazard incentives. Table 4 (Appendix) presents equations of these lines. Figure 4 shows representative graphs, though the collection of feasible region shapes is more diverse. However, we can illustrate all of the important insights using regions shown on Figure 4.
These insights will be discussed in §5. To streamline the exposition, we refrain from presenting other region shapes in the paper.

As in the case of bank financing, moral hazard-based frictions can lead to credit rationing. Projects that are above the economic viability line are financed only if they fall into a shaded region in Figure 4. Because of double-sided moral hazard, credit rationing happens for projects to the left and to the right of VC financing feasibility region. That is, both parties need to have sufficient skin in the game in order to credibly contract on exerting efforts.

### 4.3.2 Equilibrium when bank financing is an alternative to VC financing

When bank financing is available in the economy, and it is feasible to finance a project using it, VCs face competition from bank investors. This competition transfers some of the value from the VCs to the entrepreneur, whose disagreement value in negotiations with the VCs becomes $d^e = V(B, 0, s)$. Competition from bank investors also affects conditions (VF) that control double-sided moral hazard. The following Corollary to Propositions 2 and 3 formalizes the solution to this problem.

**Corollary 2.** If bank financing is feasible (see conditions in Proposition 2), then

1. If the following conditions hold
   \[
   C/\delta_C \leq \frac{(1-\theta) [V(B, C, s) - V(B, 0, s)] + C + (I-c)}{p(B, C, s)} \leq R - B/\delta_B, \tag{12}
   \]
   the negotiations between the entrepreneur and the VCs succeed; the entrepreneur and the VCs derive values $S^e = \theta [V(B, C, s) - V(B, 0, s)] + V(B, 0, s)$ and $S^v = (1-\theta) [V(B, C, s) - V(B, 0, s)]$.

2. Otherwise, (i.e., if conditions (12) are violated), the negotiations between the entrepreneur and the VCs fail, the entrepreneur uses bank financing and derives value $S^e = V(B, 0, s)$.

If bank financing is not feasible, then the outcome of the negotiations between the entrepreneur and the VCs is described in Corollary 1.

Figure 5 illustrates financing feasibility conditions in Corollary 2 graphically. We use the same variables $(L, p)$ for axes as we did in Figure 3. Two new lines introduced for Figure 5 are $\ell_4$ and $\ell_5$. Line $\ell_4$ is defined by the first inequality in (12) becoming equality and line $\ell_5$ is defined by the second inequality in (12) becoming equality. To construct this figure we applied properties of lines $\ell_1$, $\ell_4$, and $\ell_5$ as summarized in Lemma 1 in the Appendix.

From Figure 5, we observe that competition from bank investors alters the VC financing feasibility region. Specifically, for some projects (region (v)) negotiations between the entrepreneur and the VCs break down and these projects are financed by bank investors. For other projects (region (vii)), VC financing is feasible only in the presence of bank investors. The loss of VC financing in region (v) and gain of VC financing in region (vii) due to competition can be explained as follows. Bank financing provides an outside option ($d^e > 0$) for the entrepreneur during the negotiation with the VCs. As a result, the VCs capture a smaller share of the project’s value and need to contribute
more capital ("skin in the game") to exert effort in equilibrium. Therefore, VC financing becomes infeasible when the capital needed is small (region (v)), but becomes feasible when the capital needed is large (region (vii)). This effect is amplified when the success probability of the project is high, because this makes bank financing a more valuable option. Bank financing does not affect projects in region (iv) because bank financing is not feasible in this region. Finally, there are regions (i.e., region (iii)) where the only financing source for a project is banks and VC financing would not be feasible, even if banks were not present.

5 The pros and cons of successful crowdfunding

In this section we characterize the implications of a successful crowdfunding campaign. How much better are the entrepreneur and the VCs compared to an economy without crowdfunding and why? Further, can it happen that despite having had a successful campaign, the VCs or the entrepreneur would have preferred to transact in an economy without crowdfunding? Answers to these questions will prepare us for the discussion regarding the ex ante value of crowdfunding in §6.

A successful crowdfunding campaign has two consequences. It changes the entrepreneur’s pledgeable capital from $c = a$ to $c' = a - k + A$ and the project-payoff probability from $p(e, v)$ to $p'(e, v)$ (recall that ‘prime’ notation indicates a successful campaign, i.e., $s = 1$). The changes in the pledgeable capital and the project-payoff probability affect the value of project and the financing feasibility. We study changes in values and financing feasibility in §5.1, for bank-only financing and in §5.2 for VC-only financing. In addition, a successful campaign may create competition between different investor classes. We study the competition between bank and VC investors in §5.3.
5.1 Successful crowdfunding and bank-only financing

Suppose the economy has regular bank investors only. In this subsection, we identify conditions for a successful crowdfunding campaign to be beneficial to the entrepreneur (the bank being indifferent) and conditions under which the entrepreneur is worse off after a successful crowdfunding campaign, compared to an economy without crowdfunding. We shall discuss first how the values are affected if the financing feasibility does not change. Then we shall consider how crowdfunding may affect financing feasibility. Finally, we shall illustrate the two effects on a set of projects.

Let’s begin by assuming that crowdfunding does not change financing feasibility. A successful crowdfunding campaign clearly increases the project value to the entrepreneur. In the economy without crowdfunding, the entrepreneur earns \( V(B, 0) \) (defined in (1)). In the economy with crowdfunding, after a successful campaign, the value to the entrepreneur is \( V'(B, 0) \geq V(B, 0) \). Bank investors earn zero regardless of the status of crowdfunding. From Assumption 1, which is the economic value of crowdfunding is positive, we derive the following observation.

**Proposition 4.** Suppose that bank financing is feasible both in the economy without crowdfunding and in the economy with crowdfunding, after a successful campaign. Then \( V'(B, 0) - V(B, 0) \geq c - c' \) and a successful campaign benefits the entrepreneur.

A successful crowdfunding affects both the valuation of the project and the amount of capital. The condition in Proposition 4 states the even if the capital declines \((c > c')\), the increase in the value of the project \((V'(B, 0) > V(B, 0))\) will offset it.

Next, let’s consider whether crowdfunding can change the bank financing feasibility. Proposition 2 provides conditions for feasibility and Figure 3 illustrates these conditions. Consider Figure 6, which adds a set of four projects (denoted by arrows) to Figure 3 that are possible in equilibrium. These projects are chosen because they illustrate the effects of crowdfunding on the availability of bank financing. The origin of an arrow marks the position of a project in the economy without crowdfunding, i.e., \((L, p) = (I - c, p(B, 0) + \delta C)\). We marked origins by numbers 1 through 4. A crowdfunding campaign changes project characteristics. The destination of an arrow marks

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**Figure 6:** Bank financing feasibility and the effects of successful crowdfunding.

Legend: Shaded region represents bank financing feasibility conditions. Arrows represent projects and indicate changes in project characteristics, i.e., capital required \( L \) and success probability \( p \) as a result of a successful campaign. Table 4 contains line equations.
the position of a project after a successful campaign, i.e., \((L,p) = (I - c', p'(B,0) + \delta_C)\). We marked destinations by 1’ through 4’. Thus, an arrow pointing upwards indicates that crowdfunding increased the assessment of the project-payoff probability. Similarly, an arrow pointing left or right indicates that crowdfunding added or reduced the cash value to the project (decreasing or increasing the amount of the external capital required). When we refer to a project \(j\), we refer to conditions on the problem parameter values that describe the position of the arrow’s origin \(j\) and the position of the arrow’s destination \(j'\). Proposition 5 presents the effect of a successful crowdfunding on the availability of bank financing for these projects and on the value of the entrepreneur.

**Proposition 5.** Compared to the economy without crowdfunding, a successful crowdfunding campaign increases the value of projects 1 and 3 for the entrepreneur from 0 to \(V'(B,0)\), the value of project 2 from \(V(B,0)\) to \(V'(B,0)\), but decreases the value of project 4 from \(V(B,0)\) to 0.

From Figure 6 and Proposition 5 we observe that successful crowdfunding can transform economically non-viable projects (e.g., project 1) into economically viable ones. If such project is financed after a successful campaign, this increases the value of this project to the entrepreneur.

Project 2 is an example of a project where bank financing is feasible both without crowdfunding and after a successful campaign. For this project, the effect of crowdfunding is to increase its value (and therefore the value to the entrepreneur) from \(V(B,0)\) to \(V'(B,0)\), without affecting feasibility.

Project 3 is an example of a project which, although economically viable, was not receiving bank financing without crowdfunding, but receives bank financing after a successful campaign. The value of such a project changes from 0 to \(V'(B,0)\). Therefore, a successful crowdfunding campaign benefits the entrepreneur of project 3 in more ways than it does the entrepreneur holding project 2. Not only the economic value of the project 3 is increased, but also the moral hazard frictions, which prevents financing of project 3 without crowdfunding, are overcome after a successful campaign.

The last project on Figure 6, project 4, is an example of a project that has bank financing without crowdfunding, but loses it after a successful campaign. The value of such a project to the entrepreneur changes from \(V(B,0)\) to 0. This happens despite the value increase associated with a successful campaign, and even under the assumption that the ex-ante economic value of crowdfunding is positive, i.e., \(F(0) \geq 0\).

To understand why the entrepreneur of project 4 loses access to financing (or how other projects gained access to financing), let’s consider the bank financing feasibility condition (BF) in detail. For a project in the economy without crowdfunding \((c = a\) and \(s = 0)\), this condition takes form

\[
(I - a)/p(B,0) \leq R - B/\delta_B. \tag{13}
\]

For the same project after a successful campaign \((c = a - k + A\) and \(s = 1)\) the bank financing feasibility condition is

\[
(I - a)/p'(B,0) - (A - k)/p'(B,0) \leq R - B/\delta_B. \tag{14}
\]

The right hand sides of (13) and (14) are identical. Thus, the change in financing feasibility depends
on the relative values of the left hand sides, which are transfer payments $\hat{r}(a, 0)$ and $\hat{r}(a - k + A, 1)$ according to definition (6). The relationship between the two quantities is

$$\hat{r}(a - k + A, 1) = \hat{r}(a, 0) - (A - k)/p'(B, 0) - (I - a) \left( \frac{1}{p(B, 0)} - \frac{1}{p'(B, 0)} \right).$$ (15)

The last term in (15) represents the probability update value from crowdfunding. This value is always positive (for the entrepreneur) because $p(B, 0) \leq p'(B, 0)$. The probability update value reduces the payment promised to the bank, increases the value to the entrepreneur and makes it more likely that the entrepreneur exerts effort. The second to the last term is the capital value added by crowdfunding. If $A - k$ is positive, then the capital value from crowdfunding is positive, $\hat{r}(a - k + A, 1) \leq \hat{r}(a, 0)$, and feasibility condition (13) implies condition (14). However, if $A - k$ is sufficiently negative, it may happen that $\hat{r}(a - k + A, 1) > \hat{r}(a, 0)$ and the feasibility condition (14) can be violated even if the condition (13) holds. More formally, the necessary condition is

$$A - k < -(I - a) \left[ p'(B, 0)/p(B, 0) - 1 \right].$$ (16)

The following corollary to Proposition 5 delineates the two channels by which a successful crowdfunding can make bank financing infeasible.

**Corollary 3.** A successful crowdfunding campaign can make bank financing infeasible through the capital channel, but not through the project-payoff probability update. The necessary condition for bank financing to become infeasible through the capital channel is (16).

In summary, in this subsection we showed that under bank financing successful crowdfunding can be beneficial in two ways: it increases the economic value of all projects and it relaxes financing frictions with bank investors due to the entrepreneur’s moral hazard. However, in some (unusual) cases, if capital losses during a campaign are too large, crowdfunding can make bank financing infeasible. As we shall see in the subsequent discussion, the models with VC financing only and with VC and bank financing together preserve these basic insights, but also present additional ones.

### 5.2 Successful crowdfunding and VC-only financing

Suppose the economy has VCs, but no bank investors. In this subsection, we shall identify conditions under which the VCs and the entrepreneur can be better or worse off, following a successful crowdfunding campaign, compared to an economy without crowdfunding. As in §5.1, we first shall discuss how the value of the project is affected if the financing feasibility does not change. Then we shall consider how crowdfunding may affect financing feasibility. Finally, we shall illustrate the two effects on a set of projects.

First, let us assume that the financing feasibility does not change. A successful campaign increases the value of the project and the entrepreneur and the VCs share that increase. Specifically, in the economy without crowdfunding, the value of the project is $V(B, C)$. In the economy with crowdfunding, after a successful campaign, the value of the project is $V'(B, C)$. The disagreement
values for both parties are \( d^e = d^u = 0 \), because there are no alternatives for VC financing (we shall consider the case of non-zero disagreement values in §5.3). From Corollary 1, a share \( \theta \) of the project’s value goes to the entrepreneur and a share \((1 - \theta)\) goes to the VCs.

As in §5.1, the most interesting observations arise when we consider the effects of crowdfunding on financing feasibility, which is described in Corollary 1. We use Figure 7 for illustration. The arrows in this figure denote projects and indicate how the characteristics of the projects change as a result of a successful campaign. The origin of an arrow is at \((L, p) = (I - c, p(B, C))\), where \(c = a\). The destination of an arrow is at \((L, p) = (I - c', p'(B, C))\), where \(c' = a - k + A\).

**Proposition 6.** Compared with the economy without crowdfunding, a successful crowdfunding campaign increases the value of projects 1, 3 and 6 from 0 to \(V'(B, C)\), and that of project 2 from \(V(B, C)\) to \(0\). A successful campaign decreases the value of projects 4, 5, 7, and 8 from \(V(B, C)\) to 0. These values are shared between the entrepreneur and the VCs according to their bargaining powers \(\theta\) and \(1 - \theta\), respectively.

From Proposition 6 and Figure 7 we observe that, similar to the effects of successful crowdfunding on bank financing (§5.1), a successful campaign may increase the economic value of the project without changing access to financing (e.g., project 2). A successful campaign can make some projects economically viable (e.g., project 1). In addition, successful crowdfunding may help to overcome moral hazard frictions that preclude financing of economically viable projects (e.g., project 3). As we have seen for bank financing, if after a successful crowdfunding the entrepreneur’s capital decreases, \(c' < c\), the project may lose financing (e.g., project 4). The new insight from this section is that even if a campaign increased entrepreneur’s capital, \(c' > c\), the project may lose VC financing (e.g., project 5). This is because the moral hazard problem is double-sided and too much capital from the entrepreneur means too little capital from the VCs, which reduces VCs’ incentive to exert effort.

Surprisingly, a project may lose VC financing after a successful crowdfunding campaign, even if the capital does not change \(c' = c\), but the probability of the project’s success increases \(p'(B, C) > p(B, C)\) (e.g., projects 6 and 7). If we think of conditions \(\theta R \geq B/\delta_B\) and \((1 - \theta)R \geq C/\delta_C\) (in

![Figure 7: Effects of successful crowdfunding under VC financing.](image-url)

Legend: Shaded regions represent VC financing feasibility conditions as in Figure 4. Arrows represent projects and transitions of their characteristics from the economy without crowdfunding to the economy with crowdfunding after a successful crowdfunding campaign. Table 4 contains equations for lines.
Figure 7(a)) as representing a balanced bargaining power between the entrepreneur and the VCs, where both parties receive greater share of the project’s payoff than their moral hazard costs, we observe that, under the balanced bargaining power, the increased project success probability resulting from a successful campaign will always make both parties better off. However, if the bargaining power is not balanced, i.e., either \((1 - \theta)R < C/\delta_C\) (Figure 7(b)) or \(\theta R \geq B/\delta_B\) (Figure 7(c)) then as the probability increases, the benefits are incurred disproportionately by one of the parties and the other party’s moral hazard incentive compatibility constraints can be violated.

To better understand which forces affect VC financing, consider the VC financing feasibility conditions (11) in detail. For a project in the economy without crowdfunding \((s = 0\) and cash position \(c = a)\), these conditions take form \(C/\delta_C \leq V(B,C)(1 - \theta) + C + (I - a)p(B,C) \leq R - B/\delta_B\). Now, consider the same project after a successful crowdfunding campaign with \(c = a - k + A\) and \(s = 1\). The conditions (11) take the form \(C/\delta_C \leq V(B,C)(1 - \theta) + C + (I - a + k - A)p'(B,C) \leq R - B/\delta_B\). The successful crowdfunding does not change the project payoff \(R\) or the moral hazard costs \(C/\delta_C\) and \(B/\delta_B\) in (11).

The effect of crowdfunding on VC financing feasibility comes through changes in the middle term, which we called the transfer payment \(\hat{\rho}\) in (10). Because this term is constrained from above and from below, a significant change in either direction can make VC financing infeasible. There are two channels of change for the transfer payment: change in capital and change in payoff probability. To see how they work, consider the relationship between the transfer payment in the economy without crowdfunding and that after a successful campaign:

\[
\hat{\rho}(a - k + A, 1) = \hat{\rho}(a, 0) - (A - k)/p'(B,C) - \left(\frac{1}{p(B,C)} - \frac{1}{p'(B,C)}\right) [\theta(I + B + C) - (a + B)]. \tag{17}
\]

The term \(\frac{A - k}{p'(B,C)}\) captures the capital change due to the successful crowdfunding campaign. It can be positive or negative. If it is sufficiently high in absolute value, it can cause either the moral hazard constraint of the VCs or the entrepreneur to become invalid. This is similar to what we observed in §5.1. However, in this case, even a sufficiently positive \(A - k\) could preclude access to VC financing. The intuition is the same. If the entrepreneur’s pledgeable capital is too small, then the threat of losing it is not a sufficient incentive for the entrepreneur to exert effort. Conversely, if the pledgeable capital is too large, then the financial investment of the VCs is too small and the threat of losing it is not a sufficient incentive for the VCs to exert effort. In the latter case, one could wonder if the entrepreneur can pledge less than she owns. Because crowdfunding sends a public signal, it is difficult for the entrepreneur to hide her capital. But conceivably, the entrepreneur can destroy (or consume) some of the capital. However, she cannot manipulate the assessment of project-payoff probability, whose effect has similar consequences as we discuss next.

The last term in (17) represents the probability update value change. Unlike the case with bank financing in §5.1, an increase in probability does not imply a decrease in the transfer payment. Whether the effect is positive or negative depends on the sign of \(\theta(I + B + C) - (a + B)\). If the entrepreneur’s bargaining power is high \((\theta \geq (B + a)/(I + B + C))\), then a successful campaign decreases the transfer payment. Otherwise, a successful campaign increases it. Either way, a large change jeopardizes VC financing condition (11).
The following corollary to Proposition 6 delineates the two channels by which a successful crowdfunding campaign can make VC financing infeasible.

**Corollary 4.** A successful crowdfunding campaign can make VC financing infeasible through the capital channel, when \( \left| \frac{A - k}{p(B,C)} \right| \) is large (e.g., projects 4 and 5). It can also make VC financing infeasible through an increase in the project-payoff probability (e.g., projects 6 and 7).

### 5.3 Successful crowdfunding and competition between VC and bank investors

In this subsection we shall consider an economy with both VC and bank investors present. As we did in §§5.1 and 5.2, we shall identify conditions under which the entrepreneur and the investors are better or worse off after a successful crowdfunding campaign, compared to the economy without crowdfunding. However, in this subsection, we shall focus on the effect of crowdfunding on competition between VCs and banks and its consequences for financing feasibility and the distribution of values.

When financing from both investor classes is feasible, the entrepreneur uses the availability of bank financing in negotiations with VC investors. Specifically, bank financing increases the disagreement value of the entrepreneur to \( d^e = V(B, 0, s) \) (see §4.3). The access to both classes of investors is clearly beneficial for the entrepreneur, whose share of the value \( S^e \) (given in (9a)) increases in \( d^e \) and is at least \( d^e \). This share is greater than the value under bank-only financing \( d^e \) (see §4.2) and the value under VC-only financing (given by (9a) with \( d^e = 0 \), see §4.3). Therefore, if a successful campaign provides the entrepreneur with multiple financing options, crowdfunding benefits the entrepreneur. At the same time, successful crowdfunding may hurt VCs by forcing them to compete with bank investors. Whether VCs are better or worse off depends on how much of the share of the value created by crowdfunding \( V'(B, C) - V(B, C) \) is eroded by competition from banks, whose presence reduces VCs’ share by \( V'(B, 0) \).

**Proposition 7.** Suppose that in the economy without crowdfunding VC financing is feasible and bank financing is not and that, in the economy with crowdfunding, after a successful campaign, both types of financing are feasible. Then the difference in the entrepreneur’s values in these economies is

\[
[V'(B, C) - V(B, C)] \theta + V'(B, 0)(1 - \theta) - k + A \geq 0, \tag{18}
\]

The difference in the VCs’ values in these two economies is

\[
[V'(B, C) - V(B, C) - V'(B, 0)] (1 - \theta) = - [p(B, 0)R - I - B](1 - \theta) \tag{19}
\]

Expression (19) is negative (i.e., the VC is better off in the economy without crowdfunding) if and only if the project is economically viable without VC effort and with signal \( s = 0 \).

Next, let’s turn to the question of financing feasibility. It is described in Corollary 2 and illustrated on Figure 5. Similar to §§5.1 and 5.2, there are projects that gain financing, there are
projects that lose financing, and there are projects whose financing source does not change as a result of a successful campaign. We shall highlight novel insights due to competition between investor classes using Figure 8. The arrows in this figure denote projects and indicate how the characteristics of the projects change as a result of a successful campaign. Proposition 8 formalizes the discussion about the effects of crowdfunding on these projects.

**Proposition 8.** When both VC and bank financing is possible, the following holds.

(i) The values for the entrepreneur and the VCs of projects 1, 2, 3, 4 in the economy without crowdfunding and in the economy with crowdfunding after a successful campaign under different financing options are as given in Table 1.

(ii) For projects 1 and 2, both the entrepreneur and the VCs prefer to be in the economy with crowdfunding, after a successful campaign, than to be in an economy without crowdfunding. For project 3, only the entrepreneur prefers a successful crowdfunding campaign to an economy without crowdfunding. The VCs are better off in the economy without crowdfunding rather than after a successful campaign for projects 3 and 4. The entrepreneur is better off in the economy without crowdfunding for project 4 if

\[ \delta C R - C \geq (1 - \theta)(R - I - B - C). \]  

The project value lost by the entrepreneur in a successful campaign is \( [\theta V(B, C) - V'(B, 0)]^+ \).

The surprising results are in part (ii). For project 3, competition from bank investors erodes the value to the VCs. Comparing columns VC only with VC and bank in Table 1, we observe that the amount \((1 - \theta)V'(B, 0)\) is transferred from the VCs to the entrepreneur. This transfer is significant enough so that VCs would have been better off in the economy without crowdfunding, i.e., \(V(B, C) \geq V'(B, C) - V'(B, 0)\). The proof of this statement follows from expression (19). In contrast, without competition from bank investors, the VCs would have benefited from a successful crowdfunding campaign.
Table 1: Values for the entrepreneur and the VCs of projects 1, 2, 3, 4 in the economy without crowdfunding and in the economy with crowdfunding after a successful campaign under different financing options

Legend: Agent EN means entrepreneur. ‘Without CF’ column reports agents’ values in the economy without crowdfunding. ‘After a successful campaign’ columns report agents’ values in the economy with crowdfunding after a successful campaign.

<table>
<thead>
<tr>
<th>Project</th>
<th>Agent</th>
<th>Without CF</th>
<th>After a successful campaign</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bank only</td>
<td>VC only</td>
</tr>
<tr>
<td>1</td>
<td>EN</td>
<td>0</td>
<td>$V'(B,0)$</td>
</tr>
<tr>
<td></td>
<td>VCs</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>EN</td>
<td>$V(B,0)$</td>
<td>$V'(B,0)$</td>
</tr>
<tr>
<td></td>
<td>VCs</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>EN</td>
<td>$\theta V(B,C)$</td>
<td>$V'(B,0)$</td>
</tr>
<tr>
<td></td>
<td>VCs</td>
<td>$(1 - \theta)V(B,C)$</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>EN</td>
<td>$\theta V(B,C)$</td>
<td>$V'(B,0)$</td>
</tr>
<tr>
<td></td>
<td>VCs</td>
<td>$(1 - \theta)V(B,C)$</td>
<td>0</td>
</tr>
</tbody>
</table>

For project 4, competition from bank investors makes VC financing infeasible. Thus, VCs receive zero value after the campaign. In comparison, without competition from bank investors, VCs would have benefited from a successful campaign (see column VC only in Table 1). Interestingly, under conditions (20), even the entrepreneur can be better off in the economy without crowdfunding for project 4. These conditions are interpreted as: the VCs effort significantly increases the project success probability, $\delta C$, while VCs claim low share of the project’s value, proportional to $1 - \theta$. We emphasize that these results hold under the assumption that crowdfunding was both ex-ante economically valuable ($F(C) \geq 0$) and ex-post successful $s = 1$. Further, unlike the possible negative effects of crowdfunding highlighted in the previous sections, here, successful crowdfunding is detrimental due to a new economic force—competition between bank and VC investors.

6 Ex-ante value of crowdfunding

In this section we shall study the value of having crowdfunding in the economy at $t = 0$, extending the analysis presented in §5, where we compared the equilibrium contingent on the successful crowdfunding campaign at $t = 2$ with the equilibrium in the benchmark economy without crowdfunding. In §6.1, we shall present the subgame perfect equilibrium for the general model of the economy with crowdfunding at $t = 0$, before negotiations between the entrepreneur and investors take place and before the crowdfunding decision is made (see Figure 1). Then, in §6.2, we shall compare the economy with crowdfunding at $t = 0$ with the benchmark economy without crowdfunding to understand the interactions between crowdfunding and traditional financing choices ex ante and to evaluate the benefits and costs for the entrepreneurs and investors.
Subgame perfect equilibrium in the economy with crowdfunding

To describe the subgame-perfect equilibrium for the general, multi-stage model in §3, we need to specify the outcome of negotiations between the entrepreneur and investors at $t = 0$, the entrepreneur’s decision to start a campaign at $t = 1$, if negotiations at $t = 0$ failed, and the outcome of negotiations at $t = 2$, if crowdfunding was successful (see Figure 1). We also need the expected values, in equilibrium, for the entrepreneur and investors.

Negotiations at $t = 0$ are tied to negotiations at $t = 2$ through crowdfunding because the disagreement values for the $t = 0$ negotiations depend on the values at $t = 2$ and the decision to start a campaign. The calculations of the values from $t = 2$ negotiations comprise four cases, based on the type of financing that becomes available to the entrepreneur at $t = 2$. From §5.3, these four cases are VC financing with bank competition, VC-only financing, bank-only financing, and no financing. For simplicity, we shall assume that

Assumption 2. Successful crowdfunding cannot make bank financing infeasible at $t = 2$ if it is feasible at $t = 0$.

This assumption is easily satisfied if successful crowdfunding does not reduce the entrepreneur’s cash position by much (see §5.1). Assumption 2 simplifies the description of the equilibrium by eliminating game branches where bank financing becomes infeasible after a successful campaign.

Assumption 2 combined with Assumption 1 (i.e., the economic value of crowdfunding is positive) imply that starting a campaign is more valuable than investing with bank financing at $t = 0$. Therefore, when negotiating with VCs in the presence of bank competition and crowdfunding at $t = 0$, it is crowdfunding that provides the disagreement values (see §4.3) for the negotiation model. Furthermore, as long as the entrepreneur has identical financing choices at $t = 0$ and at $t = 2$ (e.g., bank only and bank only), she prefers crowdfunding over immediate investment. This further simplifies the description of the equilibrium. We can combine the description of the outcome of the $t = 0$ negotiations with the $t = 1$ decision to start a campaign. Effectively, after the negotiation, either the entrepreneur receives VC financing and invests immediately, or the entrepreneur starts a crowdfunding campaign, or the project is abandoned. We are now in the position to present the main result of this subsection.

Theorem 1. The subgame perfect equilibrium for the general, multi-stage game in §3 is described in Table 2. In this table, $t = 2$ conditions are discussed in Corollary 2 in §4.3.2.

Table 2 is divided into Conditions and Results. One should read this table left-to-right, starting with conditions at $t = 2$. For example, if at $t = 2$, after a successful campaign, conditions hold that correspond to VC financing with bank competition (Corollary 2), then without any additional conditions at $t = 0$, the negotiations between the entrepreneur and investors will fail at $t = 0$ and the entrepreneur will start a crowdfunding campaign (column ‘$t = 0$ financing or crowdfunding’). Time $t = 0$ equilibrium values to the entrepreneur and the VCs are given in the last two columns of Table 2. Let’s consider another example. If at $t = 2$, after a successful campaign, conditions
Table 2: Subgame perfect equilibrium for the general, multi-stage game in §3

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At</strong> $t = 2$</td>
<td><strong>At</strong> $t = 0$</td>
</tr>
<tr>
<td>$t = 0$ financing</td>
<td>$t = 0$ financing or crowdfunding</td>
</tr>
<tr>
<td>VCs with bank competition</td>
<td>Crowdfund</td>
</tr>
<tr>
<td><strong>VC only</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Bank only</strong></td>
<td></td>
</tr>
<tr>
<td>$V(B,C) \geq d^e$ and (VF) with $d^e = \frac{Pr(H){V'(B,0) + A} - k}{V'(B,0) + A} - k$ and $d^v = 0$</td>
<td>VC</td>
</tr>
<tr>
<td>Otherwise</td>
<td>Crowdfund</td>
</tr>
<tr>
<td>No financing</td>
<td>VC</td>
</tr>
<tr>
<td>Otherwise</td>
<td>Abandon</td>
</tr>
</tbody>
</table>

hold that correspond to bank-only financing, there are two subcases depending on the conditions at $t = 0$. First, if at $t = 0$ VC financing with disagreement values $d^e = \frac{Pr(H)\{V'(B,0) + A\} - k}{V'(B,0) + A} - k$ and $d^v = 0$ is feasible (Proposition 3), then negotiations between the entrepreneur and investors at $t = 0$ will result in VC financing and immediate investment. Second, otherwise, if at $t = 0$ such VC financing is not feasible, then the entrepreneur will start a campaign.

We observe three main outcomes in Table 2. First, VC financing with the immediate investment will happen at $t = 0$ only if, after a successful campaign at $t = 2$, the entrepreneur will have no financing or bank-only financing. Second, if there are no prospects of financing at $t = 2$ and negotiations with VCs fail at $t = 0$, the project is abandoned (last row of Table 2). Third, in other cases, negotiations at $t = 0$ fail and the entrepreneur starts a campaign.

It is convenient to visualize conditions and results of Theorem 1. We do this with the help of Figure 9. As we did with earlier figures, the axes of Figure 9 are the capital required $L$ and $p$.

Figure 9: Subgame perfect equilibrium regions

Axes: $L$ is the external capital required at $t = 0$, $p = p(B,C,0)$ is the probability of project success at $t = 0$. Colors: White means no financing in equilibrium. Purple means no crowdfunding in equilibrium; All other colors (shades of green and blue) indicate crowdfunding is adopted in equilibrium. Regions: (i), (ii) no financing in equilibrium; (iii) Bank financing at $t = 2$; (iv) VC financing at $t = 0$ with competition from crowdfunding and subsequent bank financing; (v) Bank financing at $t = 2$ (even though VC financing available at $t = 0$); (vi) VC financing with bank competition at $t = 2$; (vii) VC financing at $t = 2$ (even though VC financing available at $t = 0$); (viii) VC financing at $t = 2$ (VC financing not available at $t = 0$); (ix) VC financing at $t = 0$ (no financing available at $t = 2$).
the probability of the project’s success \( p \). But unlike previous figures, we need to plot \( t = 0 \) and \( t = 2 \) financing regions on the same figure, rather than choosing examples of projects and tracking how successful crowdfunding affects projects’ \((L, p)\) values. To capture conditions of Theorem 1, we needed to display various financing regions at \( t = 2 \), as discussed in Corollary 2 (Figure 5). These regions are expressed in variables \( L’ \) (capital required) and \( p’ \) (success probability), given that a crowdfunding campaign has been successful. To translate them into \((L, p)\)-space, we used the following relationships: \( L’ = L + \nu_L \) and \( p’ = p + \nu_p \). By assumption, a successful campaign increases assessment of success probability an, thus, \( \nu_p \geq 0 \). Quantity \( \nu_L \) can be both positive and negative, although it is natural to assume that after a successful campaign demand for capital is lower and, thus, \( \nu_L \leq 0 \). Lines from Figure 5 drawn on Figure 9 are marked with primes.

Theorem 1 also contains \( t = 0 \) conditions, including the economic viability conditions \( V(B, C) \geq 0 \), which are marked by horizontal dashed lines on Figure 9. Condition \( V(B, C) \geq d^e \) produces line \( \ell_8 \). Conditions (VF) with \( d^e = Pr(H)[V'(B, 0) + A] - k \) and \( d^o = 0 \) produce lines \( \ell_6 \) and \( \ell_7 \). Equations of all lines are in Table 4 in and their properties are given in Lemma 1 in the Appendix.

Figure 9 is representative. Although different parameter values will change slopes and intercepts of lines, the qualitative insights will not be affected. Figure 9 is also complex. Therefore, we shall discuss it in layers with the help of other figures. Subfigure 10(a) illustrates the outcome of the \( t = 0 \) negotiations and the decision to start a campaign. In the region marked \( CF \), negotiations fail and crowdfunding is used. In the region marked \( \text{no CF} \), VC financing is agreed on at \( t = 0 \) and the entrepreneur immediately invests in the project. The rest of the figure (unshaded) represents projects that are abandoned. There are only two regions where, instead of proceeding to crowdfunding, the entrepreneur and the investors decide to invest right away. Region (iv) on Figure 9 is the region where the prospect of bank financing at \( t = 2 \) is not as attractive as the immediate investment with VC investors. Region (ix) on Figure 9 is the region, where no financing would be available after a successful crowdfunding campaign and the entrepreneur and VC investors come to terms at \( t = 0 \).

For the projects that receive financing either at \( t = 0 \) or at \( t = 2 \) (after a successful campaign), Subfigure 10(b) shows whether financing is from VCs or banks, in equilibrium. Roughly speaking, bank financing is used when the loan needed is either very low or very high (although for some parameter choices the latter region disappears). For projects in the middle, VC financing is used.
6.2 Comparison between economies and the value of crowdfunding

Having presented the subgame perfect equilibrium in §6.1, we can now discuss the effects of developing crowdfunding platforms, by comparing an economy with crowdfunding to a benchmark economy without crowdfunding. The equilibrium in the benchmark economy is described in Corollary 2 in §4.3.2. We overlay graphical representation of equilibria in Figures 5 and 9, creating Figure 11. This is a complex figure with thirteen regions. To help us parse it out, we use Table 3, which contains descriptions of the equilibrium financing outcomes in the benchmark and crowdfunding economies and the effects on the change in financing, and on the VCs’ and the entrepreneur’s values. Regions are grouped by the equilibrium financing outcome in the benchmark economy. Financing outcomes are ‘-’ for no financing, ‘B’ for bank-only financing, ‘V’ for VC-only financing, and ‘Vb’ for VC financing with bank competition. For the crowdfunding economy, we present the subgame perfect equilibrium as a triple ‘(α, β, γ)’ where α is the form of financing accepted at time \(t = 0\), β is either ‘Cf’ for crowdfunding or ‘-’ for no crowdfunding, γ is the form of financing accepted at time \(t = 2\). For example, consider region (i). This is the unshaded region in Figure 11. According to Table 3, projects in this region do not receive financing in the benchmark economy, they do not receive financing in the crowdfunding economy at either time \(t = 0\) or \(t = 2\), and they are not sent for crowdfunding. Therefore, there is no change in financing, no change in VCs’ value, no change in the entrepreneur’s value from these projects, when crowdfunding is added to the economy.

The insights from Figure 11 and Table 3 are similar to those we derived for the successful crowdfunding campaigns, in §5.

**Proposition 9.** Consider Figure 11 and Table 3. Crowdfunding benefits the entrepreneur and the VCs (or one of them is indifferent) in regions (ii)-(vi), (ix), and (xiii). Crowdfunding can hurt the VCs in regions (viii), (x)-(xii). Crowdfunding can hurt the entrepreneur in regions (viii) and (xii).

Let’s discuss these results in detail. First, crowdfunding may give some projects, which would not be financed in the benchmark economy, a chance to receive financing in the crowdfunding...
Table 3: Effects of Crowdfunding, by region in Figure 11

Legend: Financing outcomes are ‘-’ for no financing, ‘B’ for bank-only financing, ‘V’ for VC-only financing, and ‘Vb’ for VC financing with bank competition. For equilibrium financing in the economy with crowdfunding we describe financing as ‘(α, β, γ)’ where α is the form of financing accepted at time t = 0, β is either ‘Cf’ for crowdfunding or ‘-’ for no crowdfunding, γ is the form of financing accepted at time t = 2. The effect of crowdfunding on the value is marked by ‘+’ if the value increases, ‘-’ if the value decreases, and ‘+/-’ if the value can either increase or decrease. If there is no effect, the cell is left blank.

<table>
<thead>
<tr>
<th>Region</th>
<th>Equilibrium financing</th>
<th>Effects of crowdfunding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Benchmark economy</td>
<td>Crowdfunding economy</td>
</tr>
<tr>
<td>(i)</td>
<td>-</td>
<td>(-,-,-)</td>
</tr>
<tr>
<td>(ii)</td>
<td>-</td>
<td>(-,Cf,B)</td>
</tr>
<tr>
<td>(iii)</td>
<td>-</td>
<td>(-,Cf,V)</td>
</tr>
<tr>
<td>(iv)</td>
<td>-</td>
<td>(-,Cf,Vb)</td>
</tr>
<tr>
<td>(v)</td>
<td>B</td>
<td>(-,Cf,B)</td>
</tr>
<tr>
<td>(vi)</td>
<td>B</td>
<td>(-,Cf,Vb)</td>
</tr>
<tr>
<td>(vii)</td>
<td>V</td>
<td>(V,-,-)</td>
</tr>
<tr>
<td>(viii)</td>
<td>V</td>
<td>(-,Cf,B)</td>
</tr>
<tr>
<td>(ix)</td>
<td>V</td>
<td>(-,Cf,V)</td>
</tr>
<tr>
<td>(x)</td>
<td>V</td>
<td>(-,Cf,Vb)</td>
</tr>
<tr>
<td>(xi)</td>
<td>Vb</td>
<td>(V,-,-)</td>
</tr>
<tr>
<td>(xii)</td>
<td>Vb</td>
<td>(-,Cf,B)</td>
</tr>
<tr>
<td>(xiii)</td>
<td>Vb</td>
<td>(-,Cf,Vb)</td>
</tr>
</tbody>
</table>

economy. Regions (ii), (iii), and (iv) on Figure 11 illustrate this. These regions are highlighted in Figure 12(a) below. In these regions, a project would have to go through crowdfunding and the campaign would have to be successful. But at the end, in region (ii) bank financing and in regions (iii) and (iv) VC financing would become available. These regions are either close to the economic viability boundary or the entrepreneur’s moral-hazard boundary. Entrepreneurs with these projects clearly benefit from having crowdfunding in the economy, and so do VCs, if VC financing is used.

Second, crowdfunding is value enhancing. Therefore, in regions where crowdfunding is used and equilibrium financing outcomes are the same in both economies, the entrepreneur and the VCs (if used) are better off in the crowdfunding economy. These regions are (v), (ix), and (xiii), as highlighted on Figure 12(b).

Third, crowdfunding may enable competition between investor classes and even alter financing outcomes to the VCs’ detriment. With competition from bank investors VCs have to cede some value to the entrepreneur. Regions (x) and (xi) illustrate this. Region (xi) is particularly interesting, because the project does not actually go through crowdfunding. Still, crowdfunding allows future bank competition to influence current negotiations between the entrepreneur and VC investors. There is bank competition in the benchmark economy as well. It is interesting that the concurrent bank competition has weaker effect than the future bank competition, enabled by crowdfunding. VCs may lose access to some projects altogether. Specifically, VC financing is replaced by bank financing (after a successful campaign) in regions (viii) and (xii). These regions are highlighted on
Figure 12(c) below. Figure 12(d) summarizes the effects of crowdfunding on VCs’ value.

Fourth, when crowdfunding deprives the project of the VCs’ contributions, this may make the entrepreneur worse off. Regions (viii) and (xii) illustrate this. Figure 12(e) summarizes the effects of crowdfunding on the entrepreneur’s value. Additional information regarding the construction of Figure 11, Figure 12, and Table 3 is provided in the Appendix.

\[
V'(B,0) \geq 0 \\
V(B,0) \geq 0 \\
V'(B,C) \geq 0 \\
V(B,C) \geq 0 \\
L
\]

\[
L
\]

(a) Crowdfunding enables financing (b) Same financing in both economies (c) VCs lose access in crowdfunding economy

\[
V'(B,0) \geq 0 \\
V(B,0) \geq 0 \\
V'(B,C) \geq 0 \\
V(B,C) \geq 0 \\
L
\]

(d) Crowdfunding and the VCs’s value (e) Crowdfunding and the entrepreneur’s value

Figure 12: Highlights of the effects of crowdfunding

7 Conclusion

Crowdfunding is a relatively recent phenomenon, but the interest in this addition to early-seed entrepreneurial financing has been remarkable. In the US alone, over $3 billion has so far flowed from backers to entrepreneurs, and success stories like that of C.H.I.P. and Oculus Rift have only strengthened the narrative that crowdfunding could present new opportunities for startups.

While our results support this narrative, they uncover a far more nuanced story, and one that is particularly relevant for successfully crowdfunded projects. We argue that crowdfunding has the potential to alter project viability through two main channels: capital and success probability. Importantly, the workings of these two channels are publicly observable, and, therefore, crowdfunding can serve as a credible signal to outside investors, such as banks and VCs. This feature, however, is a double-edged sword. In markets with financing frictions, the two aforementioned channels can combine to either increase or decrease entrepreneurs’ values, even for successful campaigns.

On the one hand, we find that crowdfunding can increase value as well as alleviate the classical under-investment problem due to moral hazard frictions. Crowdfunding may also foster competition
between investors and this benefits the entrepreneur. On the other hand, when crowdfunding leads to large enough changes in capital requirements, or when it increases the success probability too significantly, it may undermine agents’ incentives to provide effort, and this leads to negotiations breakdown. In addition, because crowdfunding may increase competition between banks and VCs, reducing returns to VC investors, VCs may choose to drop out. When this happens, the entrepreneur can be worse off because she loses out on the expertise that VCs could have added to the project. These effects also operate across time. For instance, the threat of future banks competition (enabled by crowdfunding) could change the negotiation between entrepreneurs and VCs ex-ante.

As we have shown, raising more money with more backers from crowdfunding can sometimes adversely affect access to VC financing. Therefore, an interesting future research question is how to design campaigns to produce the most desirable outcomes for the entrepreneur. Beyond reward-based platforms, which are the object of our study, crowdfunding has expanded into many different directions in the last few years, including peer-to-peer lending, real estate, and equity-crowdfunding platforms. To the extent that all of these platforms can provide cash to entrepreneurs, but also valuable information to both entrepreneurs and investors, we expect our results to apply more generally. Of course, each of these platforms have their own unique features which could bring additional insights. This presents an interesting opportunity for future research.

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Appendix

A  Notation

<table>
<thead>
<tr>
<th>First use</th>
<th>Label</th>
<th>Equation in ((L,p))-space</th>
</tr>
</thead>
<tbody>
<tr>
<td>§4.2</td>
<td>(V(B,0) = 0)</td>
<td>(p = \frac{I+B}{R} + \delta_C)</td>
</tr>
<tr>
<td></td>
<td>(\ell_1)</td>
<td>(p = \frac{L}{R-B/\delta_B} + \delta_C)</td>
</tr>
<tr>
<td>§4.3.1</td>
<td>(V(B,C) = 0)</td>
<td>(p = \frac{L+B+C}{R} + \delta_C)</td>
</tr>
<tr>
<td></td>
<td>(\ell_2)</td>
<td>(p = \frac{L+\frac{C}{(I+B+C)-(1-\theta)}(I+B+C)}{\frac{C}{\delta_C}-(1-\theta)R_B} + \delta_C)</td>
</tr>
<tr>
<td></td>
<td>(\ell_3)</td>
<td>(p = \frac{L+C/(I+B+C)-(1-\theta))(I+B+C)}{\frac{C}{\delta_C}-(1-\theta)R_B} + \delta_C)</td>
</tr>
<tr>
<td>§4.3.2</td>
<td>(\ell_4)</td>
<td>(p = \frac{L+B+C}{R-B/\delta_B} + \delta_C)</td>
</tr>
<tr>
<td></td>
<td>(\ell_5)</td>
<td>(p = \frac{L+B+C}{R-B/\delta_B} + \frac{\nu_p - \nu}{C/\delta_C} - \frac{\nu_p - \nu}{R-B/\delta_B})</td>
</tr>
<tr>
<td>§6.1</td>
<td>(V'(B,0) = 0)</td>
<td>(p = \frac{I+B}{R} + \delta_C)</td>
</tr>
<tr>
<td></td>
<td>(V'(B,C) = 0)</td>
<td>(p = \frac{I+B+C}{R-B/\delta_B} - \frac{\nu_p - \nu}{C/\delta_C} - \frac{\nu_p - \nu}{R-B/\delta_B})</td>
</tr>
</tbody>
</table>

B  Construction of figures

Figures 3-12 represent equilibrium results and are constructed using the affine lines (representing problem constraints) listed in Table 4. We collect useful properties of these lines in Lemma 1.

**Lemma 1.** Properties of lines from Table 4 are as follows:

(i) Lines \(\ell_1\) and \(\ell_5\) are parallel.

(ii) Line \(\ell_1\) runs below line \(\ell_5\) if and only if \(\theta (R - C/\delta_C) < B/\delta_B\).
(iii) Lines \( \ell_2 \) and \( \ell_3 \) intersect at \((L, p) = ((1 - \theta) - C/(I + B + C)) (I + B + C), 0)\).

(iv) Slopes of lines \( \ell_4 \) and \( \ell_5 \) are positive and the slope of line \( \ell_4 \) is greater than that of line \( \ell_5 \).

(v) Lines \( \ell_4 \) and \( \ell_5 \) intersect at point \((-\delta_C [R(1 - \theta) + \theta C/\delta_C], 0))\).

(vi) Lines \( \ell_2, \ell_4, \) and \( p = (I + B)/R + \delta_C \) intersect.

(vii) Lines \( \ell_3, \ell_5, \) and \( p = (I + B)/R + \delta_C \) intersect.

(viii) The properties of lines \( \ell_i' \), preserve the properties of lines \( \ell_i, \) for \( i = 1, \ldots, 5 \).

(ix) The slope of \( \ell_6 \) is steeper than that of \( \ell_4 \).

(x) Line \( \ell_4 \) runs above line \( \ell_4' \) if and only if \( R(1 - \theta) - C/\delta_C \leq A[1 - Pr(H)] + \theta[\Delta Pr(H) - k] \).

(xi) Line \( \ell_2' \) is parallel to line \( \ell_2 \).

(xii) Line \( \ell_2' \) runs below line \( \ell_2 \) if and only if \( A - k \geq \nu_p^{[R \delta_C(1 - \theta) - C]}\).

(xiii) Line \( \ell_8 \) is above the economic viability lines and below line \( 1 - \nu_p \) if and only if \( \frac{B + C + 1 - (B + 1)Pr(H) + [\Delta Pr(H) - k]}{1 - \nu_p - Pr(H)(1 - \delta_C)} \leq R \leq \frac{C + [\Delta Pr(H) - k]}{(\delta_C - \nu_p)}\).

C \hspace{1cm} \textbf{Proofs}

\textbf{Proof of Proposition 1.} From (2), we have \( p(B, C) = p(B, 0) + \delta_C \) and \( p'(B, C) = p'(B, 0) + \delta_C \). Using assumption that \( \delta_C' = \delta_C \) and the identity \( Pr(H) = 1 - Pr(L) \), equation (4) can be rewritten as \( F(C) = F(0) - Pr(L)(\delta_C R - C) \).

\textbf{Proof of Proposition 2.} Proposition 2 follows directly from the perfect competition assumption, which implies \( r \) defined in (5) binds to the lower bound, \( \frac{I - e}{p(B, 0, s)} \), in equilibrium.

\textbf{Proof of Proposition 3.} The solution of the Nash bargaining problem in (8) is derived from the first-order conditions, which lead to equilibrium shares given by \( S^e = (V(B, C, s) - d^e - d^e) \theta + d^e \) for the entrepreneur and \( S^v = (V(B, C, s) - d^v - d^v) (1 - \theta) + d^v \) for the VCs. The bargaining outcome is then obtained by matching the expected agent cash flows to the equilibrium shares. Letting \( \hat{\rho}(c, s) \) be the equilibrium transfer payment, we derive

\begin{align*}
    p(B, C, s)(R - \hat{\rho}(c, s)) - B - c &= S^e \quad \text{(21a)} \\
    p(B, C, s)\hat{\rho}(c, s) - C - (I - c) &= S^v. \quad \text{(21b)}
\end{align*}

From (21b), the payment is \( \hat{\rho}(c, s) = \frac{S^v + C + (I - c)}{p(B, C, s)} \). Replacing this in (7), gives the desired result.

\textbf{Proof of Corollary 1.} Follows from Proposition 3, when \( d^e = d^v = 0 \) in (VF).

\textbf{Proof of Corollary 2.} Follows from Proposition 3, when \( d^e = V(B, 0, s), d^v = 0 \) in (VF).

\textbf{Proof of Proposition 4.} From (1), we have \( V'(B, 0) - V(B, 0) \geq c - c' \), equivalently, \( V'(B, 0) + A - k - V(B, 0) \geq 0 \), where \( c' = A + a - k \) and \( c = a \). Notice \( V'(B, 0) + A - k - V(B, 0) = F(0) + (1 - Pr(H))(V'(B, 0) + A) \), with \( F(0) \) given in (4). From Proposition 1, \( F(0) > F(C) \) and from Assumption 1, \( F(C) > 0 \). Therefore, \( F(0) > 0 \). Furthermore, because \( (1 - Pr(H))(V'(B, 0) + A) > 0 \), condition \( V'(B, 0) + A - k - V(B, 0) \geq 0 \) is true.
Proof of Proposition 5. The proof consists of identifying the sets of inequalities that characterize projects 1-4. Once these are identified, existence of projects is straightforward to show by numerical construction. To ease exposition, define \( r = \hat{r}(a, 0) \) and \( r' = \hat{r}(A + a - k, 1) \). Then:

Project 1 is defined by conditions \( p(B, 0)R - I - B < 0 \cap p'(B, 0)R - I - B > 0 \cap r' > 0 \). Projects 2-4 all have in common the requirement that they are economically viable ex ante and ex post, that is, \( p(B, 0)R - I - B > 0 \), which implies \( p'(B, 0)R - I - B > 0 \) by assumption. These projects only differ on whether bank financing is available ex ante (condition (13)) and ex post (condition (14)).

Project 2 is defined by \( r < R - B/\delta_B \cap r' < R - B/\delta_B \) (BF available both ex ante and ex post). Project 3 is defined by \( r > R - B/\delta_B \cap r' < R - B/\delta_B \) (financing only available ex post). Project 4 is defined by \( r < R - B/\delta_B \cap r' > R - B/\delta_B \) (financing only available ex ante).

The statement on project values is straightforward. Projects 1 and 3 have no financing ex ante and obtain it ex post. Hence, their value goes from 0 (ex ante) to \( V_0 \) (ex post). Project 2 has financing both ex ante and ex post. Hence, its value goes from \( V(B, 0) \) (ex ante) to \( V'(B, 0) \) (ex post). Project 4 has financing ex ante, but loses it ex post. Hence, its value goes from \( V(B, 0) \) (ex ante) to 0 (ex post).

Proof of Corollary 3. As before, define \( r = \hat{r}(a, 0) \) and \( r' = \hat{r}(A + a - k, 1) \). We first derive the relationship between the two quantities \( r \) and \( r' \), given in (15). Algebraic transformations yield

\[
r' = r - \frac{A - k}{p'(B, 0)} - (I - a) \left( \frac{1}{p(B, 0)} - \frac{1}{p'(B, 0)} \right). \tag{22}
\]

By assumption, \( p'(B, 0) > p(B, 0) \). Therefore, better information (represented by the last term on the RHS of (22)) leads to \( r' < r \). From (BF) this relaxes the entrepreneur’s moral hazard constraint, and cannot break financing feasibility.

In contrast, the effect the capital change has on the transfer payment is driven by the sign of \( A - k \). A necessary condition for crowdfunding to break financing feasibility, as in project 4, is that there are sufficient cash losses to offset the informational gains. Formally, this condition is \( r' > r \), that is, crowdfunding increases the equilibrium payment to the bank, if it caused large cash losses. Condition \( r' > r \) can be written as \( A - k < -(I - a) \left( \frac{p'(B, 0)}{p(B, 0)} - 1 \right) \).

Proof of Proposition 6. The proof consists of identifying the sets of inequalities that characterize projects 1-8. Once these are identified, existence of projects follows by numerical construction. Define \( \rho' = \hat{\rho}(a, 0) \) and \( \rho' = \hat{\rho}(A + a - k, 1) \).

Project 1 is characterized by \( p(B, C)R - I - B - C < 0 \cap p'(B, C)R - I - B - C > 0 \cap \rho' > 0 \). Projects 2-8 all have in common the requirement that they are economically viable ex ante and ex post, that is, \( p(B, C)R - I - B > 0 \). These projects differ only by whether VC financing is available ex ante (condition \( C/\delta_C \leq \frac{V(B, C)(1-\theta)+C+(I-a)}{p(B, C)} \leq R - B/\delta_B \)) and/or ex post (condition \( C/\delta_C \leq \frac{V'(B, C)(1-\theta)+C+(I-a+k-A)}{p'(B, C)} \leq R - B/\delta_B \)), and by the shape of the financing region. The latter is characterized in Figure 4, by the conditions listed in the captions of 4(a)-(c). We summarize all of these additional conditions in Table 5.
Table 5: Conditions of existence for projects 2-8.

A checkmark ✓ indicates the condition holds, while ✗ indicates the condition is violated.

<table>
<thead>
<tr>
<th>Condition – Projects</th>
<th>Project 2</th>
<th>Project 3</th>
<th>Project 4</th>
<th>Project 5</th>
<th>Project 6</th>
<th>Project 7</th>
<th>Project 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho &gt; C/\delta_C )</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>( \rho &lt; R - B/\delta_B )</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>( \rho' &gt; C/\delta_C )</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>( \rho' &lt; R - B/\delta_B )</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Shape 1</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shape 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Shape 3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>

(ii) The proof of the statement on project values is straightforward. Projects 1, 3 and 6 have no financing ex ante and obtain it ex post. Hence, their value goes from 0 (ex ante) to \( V'(B,C) > 0 \) (ex post). Project 2 has financing both ex ante and ex post. Hence, its value goes from \( V(B,C) \) (ex ante) to \( V'(B,C) \) (ex post). Projects 4, 5, 6 and 8 have financing ex ante, but lose it ex post. Hence, theirs values go from \( V(B,C) \) (ex ante) to 0 (ex post).

Proof of Corollary 4. As before, define \( \rho = \hat{\rho}(a,0) \) and \( \rho' = \hat{\rho}(A+a-k,1) \). Also define \( p = p(B,C,0) \) and \( p' = p(B,C,1) \), for the purposes of this proof. Assume that crowdfunding is feasible ex ante, that is,

\[
C/\delta_C \leq \rho \leq R - B/\delta_B. \tag{23}
\]

Then, for crowdfunding to break feasibility, we must have either \( \rho' \geq R - B/\delta_B \). In which case, the entrepreneur’s incentive compatibility is violated. Or, we must have \( \rho' \leq C/\delta_C \), in which case, the VCs’ incentive compatibility is violated. To derive sufficient conditions, we isolate the cash and information effects, and study them independently. When crowdfunding affects only cash, we can show, starting from (17), that the conditions required to break each agents’ incentive compatibility can be written as:

\[
\frac{A-k}{p'(B,C)} \leq \rho - (R - B/\delta_B), \quad \text{and} \quad \frac{A-k}{p'(B,C)} \geq \rho - C/\delta_C, \tag{24}
\]

When crowdfunding affects only information, the transfer payment in (17) becomes \( \rho' = \rho - \Delta_p(\theta(B + C + I) - (a + B)) \), where we have introduced \( \Delta_p = \left( \frac{1}{p(B,C)} - \frac{1}{p'(B,C)} \right) \geq 0 \). We apply algebraic transformations to show that crowdfunded information violates the entrepreneur’s incentive compatibility if the success probability is high enough, the entrepreneur’s slope is negative and the entrepreneur’s bargaining power is low. Formally: \( p'(B,C) > \frac{a+B-\theta(B+C+I)}{B/\delta_B - R\theta} \), \( R\theta < B/\delta_B \), and \( \theta < \frac{(a+B)}{B+C+I} \). Similarly, we can show that for the VCs, the sufficient conditions for the incentive compatibility of the VCs to be violated are \( p'(B,C) > \frac{\theta(B+C+I) - (a+B)}{C/\delta_C - R(1-\theta)} \), \( R(1-\theta) < C/\delta_C \), and \( \theta > \frac{(a+B)}{B+C+I} \).
Proof of Proposition 7. Under bank financing competition, \( d^e = V(B, 0, s) \) and \( d^v = 0 \). From (9a) and (9b), the shares of each agent, ex-post successful crowdfunding, become \( S^{te} = \left(V'(B, C) - V'(B, 0)\right)\theta + V'(B, 0) \) and \( S^{te} = \left(V'(B, C) - V'(B, 0)\right)(1 - \theta) \). In the economy without crowdfunding (absent bank financing competition), the shares are \( S^e = V(B, C)\theta \) and \( S^v = V(B, C)(1 - \theta) \). The difference is:

\[
S^{te} - S^e = \left(V'(B, C) - V(B, C)\right)\theta + V'(B, 0)(1 - \theta)
\]
\[
S^{te} - S^v = \left(V'(B, C) - V(B, C) - V'(B, 0)\right)(1 - \theta) = -(p(B, 0)R - I - B)(1 - \theta).
\]

Hence, the entrepreneur’s benefit, including the change in cash position from \( a \) to \( A - k \), is given by \( S^{te} - S^e + A - k \), which is condition (18). The VC’s loss is given by \( S^{te} - S^v \) which is (19).

Proof of Proposition 8. First, we show that projects exist. The proof consists of identifying which sets of inequalities characterize projects 1-4. Once these are identified, the existence of projects above conditions in Table 6.

Define \( \rho_c(c, s) \). From (9b) and (VF), we have

\[
\rho_c(c, s) = \frac{(V(B, C, s) - V(B, 0, s))(1 - \theta) + C + (1 - c)}{p(B, C, s)} = \frac{R\delta_C(1 - \theta) + C + (1 - c)}{p(B, C, s)}.
\]

Define \( \rho'_c = \rho_c(A + I - k, 1) \) and \( \rho'_c = \rho_c(a, 0) \), to simplify the notation. The financing feasibility condition (VF) becomes \( \frac{C}{\delta C} \leq \rho_c \leq R - B / \delta_B \), ex ante, and \( \frac{C}{\delta C} \leq \rho'_c \leq R - B / \delta_B \), ex post. Combining these conditions with the standalone VC and Bank financing conditions from Sections 4.2 and 4.3, we obtain conditions describing Projects 1-4, as given in Table 6.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Projects 1</th>
<th>Projects 2</th>
<th>Projects 3</th>
<th>Projects 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r &lt; R - B / \delta_B )</td>
<td>( \times )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
</tr>
<tr>
<td>( r' &lt; R - B / \delta_B )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
</tr>
<tr>
<td>( \frac{C}{\delta C} \leq \rho &lt; R - B / \delta_B )</td>
<td>( \times )</td>
<td>( \times )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
</tr>
<tr>
<td>( \frac{C}{\delta C} \leq \rho' &lt; R - B / \delta_B )</td>
<td>( \times )</td>
<td>( \times )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
</tr>
<tr>
<td>( \frac{C}{\delta C} &lt; \rho_c &lt; R - B / \delta_B )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
</tr>
<tr>
<td>( \frac{C}{\delta C} &lt; \rho'_c &lt; R - B / \delta_B )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \checkmark )</td>
<td>( \times )</td>
</tr>
</tbody>
</table>

Part (i) of Proposition 8. The values in Table 1 follow from the financing implications of the above conditions in Table 6.

Part (ii) of Proposition 8. These results follow from the values listed in Table 1. In particular, for projects 1 and 2, both entrepreneur and VC prefer to be in an economy with crowdfunding, as their payoffs after a successful campaign Pareto-dominate their payoffs in the absence of crowdfunding. For the project 3, only the entrepreneur benefits from successful crowdfunding given her payoff \( \theta V'(B, C) + (1 - \theta) V'(B, C) > \theta V(B, C) \). The VC is worse off for projects 3 and 4. For project
3, the VC’s payoff is \((1 - \theta)(V'(B, C) - V'(B, 0)) < (1 - \theta)V'(B, C)\). For project 4, the VC’s payoff is \(0 < (1 - \theta)V'(B, C)\). Surprisingly, the entrepreneur may also be worse off for project 4, given that her value is \(V'(B, 0)\) (the bank competition causes the VC to drop out and the entrepreneur loses VC financing), whereas he could have obtained \(\theta V'(B, C)\) financed by the VC in an economy without crowdfunding. The condition \(V'(B, 0) < \theta V'(B, C)\) can be equivalently written as \(\frac{p'(B, 0) R - B - I}{p(B, C) R - B - C - I} < \theta\).

**Proof of Theorem 1.** Table 2 is divided between conditions, actions taken in equilibrium, and values. We start by deriving the first two. In an economy with a crowdfunding platform, there exist four scenarios after a successful campaign at \(t = 2\): No financing \((0)\), Bank Financing only \((B)\), VC financing only \((V)\), and VC financing under bank competition \((Vb)\). The same four financing scenarios can be feasible at \(t = 0\). After eliminating the transitions that are not feasible due to Assumption 2, we summarize the remaining possibilities in Figure 13.

![Figure 13: Feasible transitions from ex ante to ex post crowdfunding](image)

In order to characterize the \(t = 0\) negotiation outcome, we first compute the values that crowdfunding brings to each agent at \(t = 0\) (Table 7), using the \(t = 2\) subgame equilibrium values derived in Section 5. The crowdfunding values will serve as disagreement values \((d_0^e \text{ and } d_0^v)\) in the negotiations at \(t = 0\), because, as we shall show next, they dominate other outside options for the entrepreneur. There are two cases in which the entrepreneur has more than one outside option at \(t = 0\). These are transitions \(Vb \text{ to } B\) in subfigure (b) and transition \(Vb \text{ to } Vb\), in subfigure (d).

Table 7: Disagreement values at \(t = 0\) in the presence of a crowdfunding option.

<table>
<thead>
<tr>
<th>Financing feasibility at 2:</th>
<th>Entrepreneur (d_0^e)</th>
<th>Venture Capitalist (d_0^v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) No Fin.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(b) B Fin.</td>
<td>(Pr(H)[V'(B, 0) + A] - k)</td>
<td>0</td>
</tr>
<tr>
<td>(c) VC Fin.</td>
<td>(Pr(H)[\theta V'(B, C) + \hat{A}] - k)</td>
<td>(Pr(H)(1 - \theta)V'(B, C))</td>
</tr>
<tr>
<td>(d) VC&amp;B Fin.</td>
<td>(Pr(H)[\theta V'(B, C) + (1 - \theta)V'(B, 0) + A] - k)</td>
<td>(Pr(H)(1 - \theta)[V'(B, C) - V'(B, 0)])</td>
</tr>
</tbody>
</table>

In both cases, the entrepreneur has the option of bank financing at \(t = 0\), which would provide a disagreement value of \(V(B, 0)\), or the option of crowdfunding with bank financing at \(t = 2\), which would provide a disagreement value of at least \(Pr(H)[V'(B, 0) + A] - k\). From assumption Assumption 1, it follows that, \(F(0) \geq 0\), which is equivalent to \(Pr(H)[V'(B, 0) + A] - k \geq V(B, 0)\), and the option to crowdfund dominates.
Having characterized each agent’s disagreement values at \( t = 0 \), we can now describe the \( t = 0 \) negotiations. The \( t = 0 \) negotiations will succeed and lead to the immediate project investment if

\[
V(B, C) \geq d^e_0 + d^v_0, \quad \text{and} \quad C/\delta_C \leq \frac{S^e_0 + C + (1-a)}{p(B, C)} \leq R - B/\delta_B,
\]  

(27)

where \( S^e_0 \) is given by (9b), and the disagreement values \( d^e_0, d^v_0 \) are given in Table 7. Under these conditions, the entrepreneur and VC obtain value \( S^e_0 \) and \( S^v_0 \), given by (9a) and (9b), respectively. Otherwise, the entrepreneur crowdfunds. The first inequality in (27) ensures that the immediate investment generates value greater than the sum of values from disagreement. The second inequality in (27) ensures VC financing is feasible at \( t = 0 \) (this is simply condition (VF)).

For case (a) in Table 7, condition \( V(B, C) \geq d^e_0 + d^v_0 \) is equivalent to \( V(B, C) \geq 0 \), which is true. Thus, in this case, the negotiations will lead to an immediate investment if condition (VF) is satisfied. For case (b), condition \( V(B, C) \geq d^e_0 + d^v_0 \) is equivalent to \( F(0) \leq R\delta_C - C \), which may or may not hold, depending on the parameter values. For cases (c) and (d), condition \( V(B, C) \geq d^e_0 + d^v_0 \) is equivalent to \( F(C) < 0 \), which is false by Assumption 1. Therefore, in cases (c) and (d), \( t = 0 \) negotiations always fail and crowdfunding is used. These results allows us to complete the first two columns of Table 2.

The third and fourth columns of Table 2 contain the corresponding values that the equilibrium actions lead to. These are easy to obtain once the equilibrium is known. They are given by (9a) and (9b), after replacing the correct disagreement values for each agent.

Proof of Lemma 1. The properties require algebraic transformations of line definitions. Details are available upon request.