Market Imperfections and Crowdfunding*

Anton Miglo† and Victor Miglo‡

2018

Abstract

This article is the first one that considers the choice between the different types of crowdfunding and traditional financing under different types of market imperfections. In contrast to most existing literature we focus on financial aspects of crowdfunding rather than on price discrimination between customers using a new approach on the demand side. The model provides several implications, most of which have not yet been tested. For example, we find that when asymmetric information is important, high-quality projects prefer reward-based crowdfunding. A low-quality firm may find it unprofitable to mimick this strategy as it will be taking more risk to achieve a threshold. This result is contradictory to the spirit of the results in Belleflamme et al (2014), which finds that asymmetric information favours equity-based crowdfunding. In contrast to Belleflamme et al (2014), in our model, crowdfunding does not have any ad-hoc non-monetary benefits.

Keywords: crowdfunding, asymmetric information, moral hazard, equity-based crowdfunding, reward-based crowdfunding

JEL Codes: D82, G32, L11, L26, M13

1 Introduction

Crowdfunding is the practice of funding a start-up company or project by raising funds from a large number of people. It is usually performed online. In 2009 the volume of funds raised using crowdfunding was negligeably small. Crowdfunding raised $34.4 billion in 2015. Some analysts predict that crowdfunding market size will grow at an annual rate of 27.8% and will surpass venture capital investments in the near future.[1] Kickstarter, which is the leading crowdfunding

*We are grateful to the SBEJ Editor and two anonymous referees for the very helpful comments. Also, many thanks to Peter Klein, Jason Pavunkovic, Kory Lippert, Alia Raza, Shane Smith, Michael Kidd, Jamie Grasman, Jonathon Dean, Melissa Toner, Erin Clark, and all the participants of the numerous discussions on crowdfunding organized by www.journalofcapitalstructure.com website for their comments.

†Birmingham City University, anton.miglo@bcu.ac.uk.

‡University of Toronto, v.miglo@mail.utoronto.ca

[1] See, for example, Salman (2016) or a global crowdfunding report on http://crowdfundbeat.com/2016/02/03/report-global-crowdfunding-market-2016-2020/

platform in the US, has raised over $2.4 billion in pledges from 10.9 million backers to fund almost 107,000 creative ideas.[2]

Crowdfunding research is quickly growing.[3] As we are writing this article, the number of empirical papers significantly exceeds the number of theoretical papers. Empirical papers on crowdfunding have found the following: crowdfunding relaxes geographic constraints on fundraising, which inhibit venture capital and angel financing (Agrawal et al. (2010)); asymmetric information and signalling seem to play a significant role in crowdfunding (Ahlers, Cumming, Guenther, and Schweizer (2015), Hildebrand, Puri, and Rocholl (2014)); the success of a project and any potential delays are related to the volume of financing it receives (Mollick (2014)); the timing of contributions usually follows a pattern (Kuppuswamy and Bayus (2015b)). Yet, the literature on crowdfunding still lacks a full understanding of how entrepreneurs choose between different types of crowdfunding and how they decide whether to use crowdfunding or other types of financing. In this paper we try to shed some light on these questions.

Often the choice of crowdfunding method is a natural choice. "The idea of shifting equity in a business is an uncomfortable one, and the thought of having shareholders curating the direction of future business is not something you can plan for," explained John Hunt, co-founder of Mystery UK which is a subscription-based secret events company. "Our crowdfunding platform of choice was Kickstarter, which has a number of benefits, but mostly it was the appeal of rewarding those that pledge with products and services, rather than repayment or equity."[4] However, in many cases the choice is not so obvious. In fact, in most cases this choice is quite difficult. "Crowdfunding sites run either rewards-, donation-, equity-, lending- or hybrid-based funding models. Understanding how each one works and its impact on your business is of utmost importance."[5]

We focus on the two types of crowdfunding: reward-based crowdfunding (used by Kickstarter-the leading platform in the area) and equity-based crowdfunding.[6] In the case of reward-based crowdfunding, investors count on some extra-benefits from the company such as future product discounts. Under equity-based crowdfunding investors will receive shares of the company. Reward-based crowdfunding campaigns are commonly offered in one of two models. The "Keep-It-All" (KIA) model involves the entrepreneurial firm setting a fundraising goal and keeping the entire amount raised, regardless of whether or not they

[2] Kickstarter website (June 1, 2016):
https://www.kickstarter.com/help/stats?ref=about_subnav

[3] Moritz and Block (2014) and Kuppuswamy and Bayus (2015a) provide a review of the literature in this field. For international aspects of crowdfunding see, for example, Gabison (2015), Miglo (2017), or Hatfield (2017).

[4] L. Booty. October 4, 2017. Equity or reward-based crowdfunding? Hear from both sides to make your mind up. https://realbusiness.co.uk/scale-up-hub/2017/10/04/equity-reward-based-crowfunding-hear-sides-make-mind/

[5] https://www.floship.com/find-best-crowd-funding-source/

[6] The same approach is used in Belleflamme et all (2014). This paper is probably the closest to ours as we discuss below. The addition of debt-based crowdfunding does not add significantly new results to our model. We provide a more detailed discussion about this later in the article.

meet their goal, thereby allocating the risk to the crowd when an underfunded project goes ahead. The "All-Or-Nothing" (AON) model involves the entrepreneurial firm setting a fundraising goal and keeping nothing unless the goal is achieved, thereby shifting the risk to the entrepreneur. Kickstarter follows an "all or nothing" or threshold model, so funders' pledged money is only collected if the goal is reached. While other crowdfunding efforts do not always follow this model, it is currently the dominant approach to crowdfunding, and parallels the way that other funding efforts for new ventures work. Our model is also reflective of the fact that crowdfunding is an area where production decisions and finance are closely connected. The crowdfunding method choice directly and indirectly affects the development of a project and its promotion, production scale and price decisions.

As was mentioned earlier, the number of theoretical papers on crowdfunding is relatively small. Note the following. Belleflamme, Lambert, and Schwienbacher (2010) identify a number of issues related to crowdfunding from an industrial organization perspective. In their model, they analyze reward-based crowdfunding with pre-ordering and price discrimination, and find that crowdfunding should be chosen over traditional financing when fixed costs are not too large or when the discount rate is relatively large. In the second model, crowdfunding is a way to make a product better known to consumers. The authors argue that non-profit organizations tend to be more successful in using crowdfunding.

Belleflamme, Lambertz and Schwienbacher (2014) compare reward-based and equity-based crowdfunding. In either case, the funders enjoy community benefits that increase their utility.[7] It is shown that the entrepreneur prefers reward-based crowdfunding if the initial capital requirement is relatively small compared to the market size and prefers equity-based crowdfunding otherwise. Belleflamme et al (2014) also offer some extensions on the impact of quality uncertainty and information asymmetry. As the authors mentioned, further research is required. In this paper we find that when asymmetric information is important, high-quality projects prefer reward-based crowdfunding. This is contradictory, to some extent, to the spirit of the results in Belleflamme et al (2014), which finds that asymmetric information favors equity-based crowdfunding. Note, however, that the objective of their analysis is different from ours. For example, they do not analyze the case when the decision about the choice

[7] In Belleflamme et al (2014) price discrimination is not possible in the absence of non-monetary benefits, and therefore both forms of crowdfunding yield exactly the same outcome as seeking money from a bank or large equity investors. Some research discovered, however, that the role of such non-monetary benefits in crowdfunding is negligeable (see, for example, Cholakova and Bart (2015)). In our model, there are no non-monetary benefits from crowdfunding but the benefits/costs of crowdfunding (compared to traditional financing) arise from natural features of crowdfunding such as market feedback, close connections between production and financing, moral hazard, asymmetric information etc. Note that overall, the focus of most existing theoretical papers on cowdfunding has been to exploit features of crowdfunding like the opportunity for the entrepreneur to price discriminate. However, recent literature finds empirically that market imperfections play a significant role in crowdfunding. Hence, our article mostly focuses on the latter.

of crowdfunding type is part of the model (this is obviously a crucial part of our model; consequently they automatically do not consider the possibility that firms can signal their quality with their choice of crowdfunding) so they only compare the symmetric and asymmetric information cases within each type of crowdfunding.[8]

Among other theoretical papers on crowdfunding note the following. Strausz (2017) studies entrepreneurs' interactions with customers before investment using the mechanism design approach. Under aggregate demand uncertainty, crowdfunding improves the screening of potential customers. Entrepreneurial moral hazard threatens this benefit. Studying the subsequent trade-off between screening and moral hazard, the paper characterizes optimal mechanisms. Efficiency is sustainable only if returns exceed investment costs by a margin reflecting the degree of moral hazard. Constrained efficient mechanisms exhibit underinvestment.

Hu, Li, and Shi (2014) study the optimal product and pricing decisions in a crowdfunding all-or-nothing mechanism. When the buyers are sufficiently heterogenous in their product valuations, the creator should offer a line of products with different levels of product quality. Compared to the traditional situation where orders are placed and fulfilled individually, with the crowdfunding mechanism a product line is more likely to be optimal than a single product and the quality gap between products is smaller. The paper also shows the effect of the crowdfunding mechanism on pricing dynamics over time. Together, these results underscore the substantial influence of the emerging crowdfunding mechanisms on common marketing decisions.

We build a model of crowdfunding that deals with the aggregate demand function for a firm's product/service. While most existing literature takes an industrial organization approach with a focus on invidiviudal demands and price discimination, our approach is more in the spirit of financing literature. We focus on the role of asymmetric information and moral hazard. When analyzing the role of asymmetric information, we assume that insiders have more information about the firm than outside investors/funders. However, in contrast to traditional capital structure literature where the amount of investment is usually given in advance our model takes into consideration the flexibility of crowdfunding where the volume of investments is driven by the demand of the customers/funders. In addition, our model incorporates other major features of crowdfunding. For example, in the case of crowdfunding the market provides intense feedback regarding a firm's projects and products. Unlike venture capital and bank financing, there are no major investors with crowdfunding, who often maintain a certain degree of monitoring and control over the firm's activities. As a result, the entrepreneur may be subject to a higher degree of moral hazard (Agrawal, Catalini, and Goldfarb (2013), Moritz and Block (2014), Strausz (2017)).

We find that when asymmetric information prevails, equity-based crowd-

[8] Among other things note, for example, that the proof of Lemma 5, which is crucial for Proposition 2, relies on numerical simulations, Section 4.2.2 is not finished and, as mentioned above, the case when the choice of crowdfunding type is part of the model is not analyzed.

funding suffers more from asymmetric information, which is consistent with the spirit of the majority of finance literature where equity-financing is generally most sensitive to the asymmetric information problem. Equity-based crowdfuning cannot be used as a signalling tool by a high-quality firm since it will be mimicked by a low-quality firm as the share price of a high-quality firm is higher than that of a low-quality firm. In contrast, a high-quality firm can use reward-based crowdfunding especially the AON scheme. This is because a low-quality firm may find it unprofitable to mimick this strategy as it will be taking more risk to achieve a threshold. This prediction has not been directly tested but is consistent with the spirit of the results found in Ahlers, Cumming, Guenther, and Schweizer (2015) and Mollick (2014) (that the firm's financing choice can serve as a signal of a project's quality). Reward-based crowdfunding also dominates when the moral hazard problem prevails since it implies a higher fraction of ownership held by the entrepreneur compared to equity-based crowdfunding. The entrepreneur's larger fraction of equity is associated with a higher project quality. Ahlers et al (2015) examine the effectiveness of the signals used by entrepreneurs to induce (small) investors to commit financial resources in an equity-based crowdfunding context. They found that retaining equity is an effective signal and can therefore strongly impact the probability of a funding's success. It is consistent with the spirit of our result that reward-based crowdfunding may be preferred by entrepreneurs of higher quality.

Traditional bank financing may lead to bankruptcy if the firm is unsuccessful. So the magnitude of the bankruptcy cost plays a role in the financing method choice. If these costs are high enough, the entrepreneur may prefer crowdfunding since, formally, crowdfunding does not neccessarily lead to bankruptcy if the crowdfunding campaign or production fail.[9] However, under reward-based crowdfunding, indirect costs of distress may arise related to the consumer protection law in case products are not delivered to customers. We find that a separating equilibrium where high-quality firms select reward-based crowdfunding can only exist if these costs are relatively high. Also, unlike traditional financing, crowdfunding provides market feedback. When this feature of crowdfunding is introduced into the basic model, we find that crowdfunding is selected over a traditional bank loan if the demand for the product is either very small or very large. Finally, as mentioned above, crowdfunding may be subject to some specific moral hazard problems. We combine two types of moral hazard (one related to the costly entrepreneurial effort and the other related to the entrepreneur's decision of whether to continue the project's development or withdraw (Chang (2016), Chemla and Tinn (2017) and Strausz (2017)) and find a nonlinear realtionship between a firm's quality (or probability of bankruptcy) and the likelihood of choosing crowdfunding vs. bank loan. This is in contrast to Chemla and Tinn (2017) which finds that the extent of the moral hazard makes

[9] In most countries there is no formal regulation that can be used to force a company into bankruptcy in the case of crowdfunding (see, for example, Gabison (2015) or Moores (2015)). There is a difference, however, between equity-based and reward-based crowdfunding. If the firm uses reward-based crowdfunding then the consumers are under the consumer protection law etc. (Gabison (2015)). We consider this aspect in Section 5.

it less likely for the firm to select crowdfunding. We find that a bank loan will be preferred to crowdfunding when the probability of bankpructy is either very small or very large. In the former case the entrepreneur cannot credibly commit to the project's continuation in case the firm decides to use crowdfunding.

Next we discuss the possiblity of creating a more global model of crowdfunding which can incorporate many different features discussed above simultaneously. This is a very challenging task and at this stage of crowdfunding theory development it is probably better to focus on the analysis of separate factors. Nonetheless, we also present several "hybrid" cases that incorporate several factors and generate new results. Further analysis is required.

The rest of the paper is organized as follows. Section 2 describes the basic model and some preliminary results. Section 3 through 6 discuss the consequences of introducing different kinds of market imperfections into the basic model and their implications for crowdfunding decisions. Section 7 discusses the model's robustness and its potential extensions. Section 8 analyzes cases that involve several market imperfections simultaneously. Section 9 discusses the consistency of the model's predictions with observed empirical evidence and Section 10 is a conclusion to the study.

Table 1. Variables and notations description.

Variable	*Description*
a	parameter in the demand function
a_j	parameter in the demand function for type j firm in a model with asymmetric information
c	unit cost
c_j	unit cost for type j firm in a model with asymmetric information
I	investment
q	quantity produced
q_t	quantity produced in period t in a two-period model
p	product price
p_t	product price in period t in a two-period model
α	fraction of shares sold to investors
α_j	fraction of shares sold to investors by type j firm in a model with asymmetric information
M	amount of funds raised using equity-based crowdfunding
M_j	amount of funds raised using equity-based crowdfunding by type j firm in a model with asymmetric information
e	the entrepreneur's level of effort
δ	0 or 1 parameter in the demand function
γ	probability of bankruptcy
Q	0 or 1 parameter of production success
b	private benefit of entrepreneur

2 Basic Model

An entrepreneurial firm has monopoly power over its innovative product or service. If the firm produces q units, it costs cq in total.[10,11] The demand for the good is given by the inverse demand function $q = a - p$.[12] Under reward-based crowdfunding the firm collects pre-orders for its future product or service. Under equity-based crowdfunding, the firm sells a fraction α of the firm. Funders and entrepreneurs are assumed to be risk-neutral and the risk-free interest rate is 0. If the firm selects reward-based crowdfunding, it has two options: KIA (keep-it-all) or AON (all-or-nothing). If AON is selected, a threshold T is set, $T > 0$. If the amount of funds raised is less than T, the firm is liquidated.

First consider the symmetric information case for the different types of crowdfunding.

2.1 Reward-Based Crowdfunding: KIA

The timing of events is as follows:

1. Firm selects p.
2. The demand for the product is determined, $q = a - p$.
3. If $pq < cq$, the firm is liquidated (so p should not be less than c).
4. Otherwise, the entrepreneur collects profit $pq - cq$.[13]

[10] Section 7 discusses model extensions and robustness with regard to the inclusion of fixed costs.

[11] All variables are described in Table 1.

[12] Some papers use the approach where, for example, there are individual customers with different demand functions (see, for example, Belleflamme et al (2014) and Hu, Li and Shi (2014)). Section 7 discusses the model's robustness with regard to changes in the demand functions.

[13] Note that the focus of our paper is not on price discrimination between consumers (industrial organization approach). Most other papers that focus on reward-based crowdfunding have a separate pre-sale stage where the firm tries to receive information about consumers' valuation before starting the retail stage. This scenario is well studied (at least compared to other approaches). Consumer' valuation is common knowledge in our paper. So the focus is really on other features of crowdfunding such as private information about production cost in the case of reward-based crowdfunding or moral hazard issues that generate new results compared to existing literature. Note that in other papers too if one assumes that consumerS' valuation is common knowledge, the modelling of price decisions would be the same as in our paper i.e. it would make no sense to separate the pre-sale and retail stages (at least in terms of modelling price determination). Also note that informational interactions (and informational games) between the firm and market participants is a big part of our model. For example, the market feedback is modelled in Section 8 but rather than providing information about consumerS' valuation it provides valuable information for the firm in terms of improving the product quality in period 2 (in the case of the two-period model). Secondly, in many cases the retail stage does not even exist. The number of backers/funders is so large and the number of pre-orders is so large that the firm starts focusing on delivering these pre-orders immediately after the campaign ends and does not open it for further sales (see, for example, https://www.huffingtonpost.com/chris-shuptrine/kickstarter-crowdfunding-_b_9609322.html).

The firm selects a pre-order price in order to maximize its profits. The constraint, however, comes from the necessity to collect the amount of money required to launch production.

The firm maximizes $\Pi = pq - cq = (p-c)q = (p-c)(a-p)$ subject to: $p \geq c$.

The solution is:

$$p = \frac{a+c}{2} \tag{1}$$

The firm's expected profit then equals

$$\Pi = \frac{(a-c)^2}{4} \tag{2}$$

Note that $p \geq c$ if and only if

$$a \geq c \tag{3}$$

If (3) fails, the firm will not be able to raise the funds needed to launch production. When the cost of production is too large or the demand for the firm's product/service is too low, the project is not worth undertaking. This comment can be applied to every type of crowdfunding analyzed below.

2.2 Reward-Based Crowdfunding: AON

The timing of events is as follows:

1. Firm selects T and p, $p \geq c$.
2. The demand for the product is determined, $q = a - p$.
3. If $pq < T$, the firm is liquidated.
4. Otherwise, the entrepreneur collects profit $(p-c)(a-p)$.

The firm chooses T and p to maximize Π where $\Pi = (p-c)(a-p)$ if $pq = p(a-p) \geq T$ and $\Pi = 0$ if $pq = p(a-p) < T$.

The solution is any T such as $T \leq p(a-p)$ where $p = \frac{a+c}{2}$, which implies $T \leq \frac{a^2-c^2}{4}$.

The firm's expected profit equals

$$\Pi = \frac{(a-c)^2}{4}$$

This is the same amount as in (2).

2.3 Equity-Based Crowdfunding

The timing of events is as follows:

1. Firm selects α (the fraction of the firm to sell) and sells α for price M.
2. Firm selects p. The demand for the product is then determined: $q = a - p$.
3. If $M < cq$, the firm is liquidated.

After shares are sold, the firm chooses p to maximize the entrepreneur's expected profit:

$$(1-\alpha)(p(a-p) + M - cq) = (1-\alpha)(p(a-p) + M - c(a-p)) \tag{4}$$

subject to

$$M \geq cq = c(a-p) \tag{5}$$

Two cases are possible. 1.

$$M \geq \frac{c(a-c)}{2} \tag{6}$$

In this case the firm will be able to produce an optimal quantity of goods/services, i.e. it can select the p that is the absolute maximum for (4) as the constraint (5) is not binding. This price equals $p = \frac{a+c}{2}$. The cost of production is $cq = c(a - \frac{a+c}{2}) = \frac{c(a-c)}{2} \leq M$ so the constraint (5) holds.

The entrepreneur's expected profit equals

$$(1-\alpha)(\frac{(a-c)^2}{4} + M) \tag{7}$$

The funders' expected earnings should cover their investment cost or:

$$\alpha(\frac{(a-c)^2}{4} + M) \geq M \tag{8}$$

For the optimal solution the condition (8) will be binded because the firm can always make α as small as necessary. Then we have:

$$\alpha = \frac{4M}{(a-c)^2 + 4M} \tag{9}$$

Substituting this into (7), we find that the entrepreneur's expected profit equals:

$$\frac{(a-c)^2}{4}$$

2. $M < \frac{c(a-c)}{2}$. In this case the firm will not be able to produce an optimal quantity of goods/services. We have $q = \frac{M}{c}$ (as long as $p \geq c$, the firm will produce as much quantity as possible) and $p = a - \frac{M}{c}$.

The entrepreneur's expected profit then equals

$$(1-\alpha)\frac{M}{c}(a-\frac{M}{c}) \tag{10}$$

The funders' expected earnings should cover their investment cost or:

$$\alpha\frac{M}{c}(a-\frac{M}{c}) \geq M \tag{11}$$

For the optimal solution the condition (11) will be binded as was mentioned earlier. Then we have:

$$\alpha = \frac{c^2}{ac-M}$$

Substituting this into (10), we find that the entrepreneur's expected profit equals:

$$\frac{(ac-M-c^2)M}{c^2}$$

This is less than the expected profit ($\frac{(a-c)^2}{4}$) in the case when $M \geq \frac{c(a-c)}{2}$. The optimal solution is then $M \geq \frac{c(a-c)}{2}$, $\alpha = \frac{4M}{(a-c)^2+4M}$ and $p = \frac{a+c}{2}$. The entrepreneur's profit equals

$$\frac{(a-c)^2}{4}$$

Again, this is the same amount as in (2). This is not surprising given that in the absence of any financial market imperfections every type of financing should have the same result (similar to Modigliani-Miller proposition (1958)) as long as they fit into the budget constraints.

Lemma 1. *If $a \geq c$: 1) the firm is indifferent between different types of crowdfunding; 2) if AON is selected, $T \leq \frac{a^2-c^2}{4}$; 3) if equity-based crowdfunding is selected, $M \geq \frac{c(a-c)}{2}$ and $\alpha = \frac{4M}{(a-c)^2+4M}$. If $a < c$, the project will not be undertaken.*

The proof of this lemma follows from the above analysis.

3 Moral hazard: costly entrepreneurial effort

So far we assumed that the decisions about α and p are made simultaneously. We know, however, that under equity-based crowdfunding, the entrepreneur's share of the company is less than 100% after funds are raised and therefore the entrepreneur's incentive may be different than it would be under reward-based crowdfunding.[14] Hence, we consider a situation where the cost of production also includes the entrepreneur's own effort. We assume that this effort costs eq. Following similar calculations to those in the previous subsection, one can

[14] This is a classic moral hazard idea (Jensen and Meckling, 1976).

see that under reward-based crowdfunding[15] $p = \frac{a+c+e}{2}$ and the entrepreneur's profit equals

$$\frac{(a-c-e)^2}{4} \tag{12}$$

Consider equity-based crowdfunding. The timing of events is the same as in Section 2.3.

Proposition 1. *If $a - c \geq e$: 1) the firm prefers reward-based crowdfunding; 2) prices are higher and the quantity produced is lower under equity-based crowdfunding than under reward-based crowdfunding. If $a - c < e$, the project will not be undertaken.*

Proof. See Appendix.

As shown in the Appendix, $p = \frac{a+c+e/(1-\alpha)}{2}$. Under equity-based crowdfunding, the price is higher than it is under reward-based crowdfunding. This is intuitive because the entrepreneur reaps less than 100% of the benefits from increasing production while bears a non-shared extra-cost, therefore, the entrepreneur chooses a lower level of production.

It is also shown that the entrepreneur's profit equals

$$\frac{(a-c)^2}{4} - \frac{e^2}{4(1-\alpha)^2} + \frac{e^2}{2(1-\alpha)} - \frac{ea}{2} + \frac{ec}{2} \tag{13}$$

If $\alpha = 0$, (13) will be equal to $\frac{(a-c-e)^2}{4}$. It was mentioned above that it would be the same value as it would be in the case of reward-based crowdfunding. When α is positive, the entrepreneur's profit under equity crowdfunding will be smaller since the derivative of (13) with respect to α is negative. It is consistent with the idea of agency cost.

4 Asymmetric information about cost

Now consider the case of asymmetric information about the cost of production.[16] Suppose that the firm can be either a low-cost (high-efficiency) producer (denoted l) or a high cost (low-efficiency) producer (denoted h). More specifically, suppose that c is either equal to c_l or c_h and $c_l < c_h$. Initially the firm's type (the value of c) is determined and becomes known to the entrepreneur. Also let us assume that the fraction of type l firms equals x.

The timing of events is as follows:

1. The firm's type is revealed to the entrepreneur.

[15] In this section there is no difference between AON and KIA since asymmetric information is related to the cost of prodcution and there is no demand uncertainty. When using AON, the firm should just follow the rule regarding the choice of T established in Lemma 1. In fact, the same holds in all model variations in a one-period setting. Further, we consider a two-period variation with demand uncertainty for the firm's product/service. In this case the risk of failure exists if the firm choses AON creating a difference between AON and KIA.

[16] Later we consider the case when asymmetric information exists regarding the demand for a firm's product/service.

2. Firm selects financing strategy: reward-based crowdfunding or equity-based crowdfunding.

3. If equity-based crowfunding was selected, the firm selects α and sells α for price M.

4. The firm selects p. The demand for the product is determined, $q = a - p$.

5. If equity-based crowfunding was selected and $M < cq$, the firm is liquidated.

6. If reward-based crowdfunding was selected and $p < c$, the firm is liquidated.

An equilibrium is defined as a situation where no firm type has an incentive to deviate. Under equity-based crowdfunding, the price that potential investors will be paying for a fraction of a firm's shares depends on their beliefs about the firm's production cost. This leads to the point that if a separating equilibrium (an equilibrium where firms select different strategies) exists, it will not be one where the high-efficiency type chooses equity-based crowdfunding since it will always be mimicked by the low-efficiency type. This result is typical for basic models with asymmetric information beginning with Akerloff (1970). On the other hand, since private information only concerns the production cost and not the demand side, the informational game does not affect the outcome of reward-based crowdfunding. Firms will select their prices as in the case with perfect information and demand will be determined by the demand function, which is publicly known in this scenario.

Proposition 2. *1) A separating equilibrium exists, where type l selects reward-based and type h selects equity-based crowdfunding; 2) a separating equilibrium where type l selects equity-based crowdfunding does not exist.*

Proof. See Appendix.

Next we analyze the pooling equilibria. We define a pooling equilbrium as one where both types of firms select the same strategy. We will also check that the off-equilibrium beliefs of market participants survive the intuitive criterion by Cho-Kreps (1987). This condition means that the market off-equilibrium beliefs are reasonable in the sense that if for any firm type its maximal payoff from deviation is not greater than its equilibrium payoff then the market should place the probability 0 on possible deviations of this type. The definitions above are consistent with the standard perfect bayesian equilibrium definition (see, for instance, Fudenberg and Tirole, 1991) with the addition of an intuitive criterion that is quite common in these types of games (see, for instance, Nachman and Noe, 1994). If multiple pooling equiliria exist we will use the mispricing criterion to indicate the one that is most likely to exist. We use the standard concept of mispricing that can be found, for example, in Nachman and Noe (1994). The magnitude of mispricing in a given equilibrium is equal to that of undervalued type(s). The overvaluation of overvalued type(s) does not matter.

Proposition 3. *1) Pooling with reward-based crowdfunding is an equilibrium; 2) if pooling with equity-based crowdfuning exists, then mispricing is larger under that than under the pooling equilibria with reward-based crowdfunding.*

Proof. See Appendix.

The idea behind Proposition 3 is simple. As was mentioned previously, reward-based crowdfunding is not affected by asymmetric information. The result of this analysis is that asymmetric information favors reward-based crowdfunding. Asymmetric information does not favor equity-based crowdfunding. This is consistent with the pecking-order theory by Myers and Majluf (1984).

5 Bankruptcy costs and bank monitoring

In this section we compare crowdfunding with bank financing. If a firm takes a bank loan and it is not able to pay back its debt then the firm is bankrupt and there are bankruptcy costs. On the other hand, banks have a better ability to monitor and control entrepreneurs.[17] So we assume that the manager (managerial team) has some private benefits b from each unit produced at the expense of the firm when the firm uses crowdufunding. Strausz (2017) analyzes a similar concept of moral hazard.[18] The focus of that paper is mostly on reward-based crowdfunding and more specifically AON. As was mentioned earlier our focus is primarily on the choice between crowdfunding methods and between crowdfunding and a bank loan. Chang (2016) also focuses on reward-based crowdfunding. The moral hazard problem is the decision whether to invest (to continue with the proejct after observing the amount of funds raised) or to default. Later we will use this approach as well. Compared to our paper, their model has a different approach to modelling the demand side. Chemla and Tinn (2017) is probably closest to our model in that it compares different financing strategies under moral hazard consideration.[19] However they model the demand side differently and they do not compare crowdfunding with bank financing. To simplify the calculations related to bankruptcy we assume that the production output is stochastic and depends on parameter Q (similar to stochastic demand in Section 5): $Q = 1$ with probability γ and 0 with probability $1 - \gamma$. This implies that bankruptcy will only occur if the firm takes a bank loan and $Q = 0$. The bankruptcy costs are denoted by B. As was previously discussed, in contrast to firm liquidation cases when the required financing is not raised, bankruptcy does not occur as a result of failed production if the firm uses crowdfunding.

The timing of events is as follows:

1. Firm selects financing strategy: bank loan or crowdfunding.

2. Firm selects p.

[17] See, for example, Diamond (1984).
[18] Also see Xue (2017).
[19] They focus on the choice between AON and KIA.

3. Q becomes known. If $Q = 0$ and bank loan was selected, the firm is bankrupt.

Lemma 2. *1) Prices are higher and quantity produced is lower under crowdfunding. 2) For given values of a, B and γ, the firm chooses to take a bank loan if b is sufficiently large; for given values of a, B and b, the firm chooses to take a bank loan if γ is sufficiently large; for given values of γ, B and b, the firm chooses to take a bank loan if a is sufficiently large.*

Proof. See Appendix.

We find that the product price under bank financing is $p = \frac{a+c/\gamma}{2}$ and $p = \frac{a+(b+c)/\gamma}{2}$ under crowdfunding**.** Prices are higher and quantity produced is lower under crowdfunding because of the extra-cost related to moral hazard issues. The second part of the proposition states that crowdfunding will be preferred if the cost related to the absence of monitoring is relatively small, bankruptcy costs are relatively high and the probability of bankruptcy is relatively small. Otherwise, a bank loan will be preferred. These results are very intuitive.

Next we consider a different approach. In general, as mentioned in, for example, Strausz (2017) the outcome of modelling moral hazard problems in crowdfunding is quite sensitive to the way they are determined. In the spirit of Chang (2016), Chemla and Tinn (2017) and Strausz (2017) we assume that after funds are raised from crowdfunding, the manager (managerial team) can decide whether to begin production or take the funds and "run away". The idea is that the quality of the project can play in favor of crowdfunding. The higher the quality of the project, the greater the probability that the decision-maker will select it.

The timing of events is as follows:

1. Firm selects financing strategy: bank loan or crowdfunding.
2. If bank loan is selected, the firm selects D.
3. If crowdfunding is selected, the firm selects α and sells α for M.
4. If crowdfunding was selected, the entrepreneur decides whether to begin production or to run away.
5. Firm selects p.
6. Q becomes known. If $Q = 0$ and bank loan was selected, the firm is bankrupt.

Proposition 4. *When $b = 0$, the firm selects bank loan if and only if*

$$\gamma < \frac{3c}{a} \tag{14}$$

When $b > 0$, the firm selects bank loan if and only if γ is very small or very large.

Proof. See Appendix.

Overall we find that the condition (14) is consistent with the spirit of Strausz (2017) and Chemla and Tinn (2017) in that the extent of the moral hazard or the magnitude of production cost (variable cost in Chemla and Tinn (2017)) makes it less likely for the firm to select crowdfunding. However, for the case $b > 0$ we find that the link between the firm's performance and the crowdfunding choice is not linear. A bank loan is preferred when either the probability of bankruptcy is very low (the firm cannot credibly commit to project continuation) or when it is very high (the risk of bankruptcy diminishes and the importance of bankpructy cost is smaller compared to entrepreneurial moral hazard in the form of private benefits, which is consistent with the spirit of Lemma 2).

6 Two periods

A two-period extension is very natural. First, it clearly illustrates the difference between AON and KIA. In the model with uncertain demand, when the campaign fails there is an extra-cost in the form of lost earnings in period 2 in case a firm uses AON. Another role of the second period in the model is related to market feedback because it will affect the entrepreneur's information in period 2. Also, a two-stage model reveals the difference between the long-term character of earnings in the case of equity-based crowdfunding vs. short-term rewards in the case of reward-based crowdfunding. Finally, some recent literature suggests that considering consequtive stages of firm crowdfunding is becoming quite popular (see, for example, Xue (2017)).

In period $t = 1, 2$, if the firm produces q_t units, it costs cq_t in total. The demand is as follows: $q_t = a - p_t$. Under reward-based crowdfunding the firm collects pre-orders for period 1. Since crowdfunding is usually used to cover the start-up costs, period 2 financing is not explicitly modelled. The capital structure and the ownership structure will be the same in period 2 as they are at the end of period 1. Under symmetric information, the calculations are very similar to Section 2 (omitted for brevity). We have $p_1 = p_2 = \frac{a+c}{2}$ and the firm's profit over the two periods equals $\Pi = \frac{(a-c)^2}{2}$. In fact Lemma 1 holds for a two-period model. It means that under symmetric information, the firm is indifferent between different types of crowdfunding (note again that it is similar to the Modigliani-Miller proposition (1958)). Also note that if AON is selected, $T \leq \frac{a^2-c^2}{4}$. If equity-based crowdfunding is selected, $M = \frac{c(a-c)}{2}$ and $\alpha = \frac{2M}{(a-c)^2+2M}$.

6.1 Demand uncertainty

Some empirical research suggests that it is very typical in crowdfunding for projects to attract very low or negligeably small amounts of funds (see, for example, Mollick (2014), Cordova, Dolci and Gianfrate (2015) and Desjardins (2016)). In our previous analysis, when the demand function is known with certainty, the firm can choose a threshold T (under AON) such that the probability of not rasing a sufficient amount of funds is zero. We know, however, that

many crowdfunding campaigns fail. In this section we analyze a case where the failure of a crowdfunding campaign is unavoidable under AON if the demand is very low or absent. Let us assume that the period t demand is as follows: $q_t = \delta_t(a - p_t)$, where $\delta_t = 1$ with probability π and 0 with probability $1 - \pi$. δ_t is the demand "shock".[20] If $\delta_t = 0$, the demand for the firm's product does not exist. Note that in a one-period setting the demand uncertainty would not bring any significantly new results. The reason is that even if the firm fails under AON there is no cost of lost earnings in period 2.

The timing of events is as follows:

1. Firm selects financing strategy: KIA, AON or equity-based crowdfunding. If AON is selected, the firm selects T.
2. If equity-based crowdfunding is selected, the firm selects α and sells it for an amount M.
3. δ_1 becomes known.
4. Firm selects $p_1 \geq c$. q_1 is determined.
5. If AON is selected and $p_1 q_1 < T$, the firm is liquidated.
6. If equity-based crowdfunding is selected and $M < cq_1$, the firm is liquidated.
7. δ_2 becomes known.
8. Firm selects p_2.[21]

[20] In Section 7, we discuss an extension with a different "shock" function.

[21] Note that the focus of our paper is not on price discrimination between consumers (industrial organization approach). Most other papers that focus on reward-based crowdfunding have a separate pre-sale stage where the firm tries to receive information about consumers' valuation before starting the retail stage. This scenario is well studied (at least compared to other approaches). Consumers' valuation is common knowledge in our paper. So the focus is really on other features of crowdfunding such as private information about production cost in the case of reward-based crowdfunding or moral hazard issues that generate new results compared to existing literature. Note that in other papers too if one assumes that consumers' valuation is common knowledge, the modelling of price decisions would be the same as in our paper i.e. it would make no sense to separate the pre-sale and retail stages (at least in terms of modelling price determination). Also note that informational interactions (and informational games) between the firm and market participants is a big part of our model. For example, the market feedback is modelled in Section 7 but rather than providing information about consumers' valuation it provides valuable information for the firm in terms of improving the product quality in period 2 (in the case of the two-period model). Second interpretation is that in many cases the retail stage does not even exist. The number of backers/funders is so large and the number of pre-orders is so large that the firm starts focusing on delivering these pre-orders immediately after the campaign ends and does not open it for further sales (see, for example, https://www.huffingtonpost.com/chris-shuptrine/kickstarter-crowdfunding-_b_9609322.html). Third interpretation (for a two-period model) is that the delivery of pre-orders and retail stage customers' orders is separated in time and that the consumers may have different preferences for the product at different moments in time (for a two-stage model). So in a two-stage model the second stage may be interpreted as a retail stage. It may be advantageous for the firm to use

Consider AON. In period 2, if $\delta_2 = 1$ and $q = a - p_2$, the firm chooses p_2 to maximize $(p_2 - c)(a - p_2)$, which makes $p_2 = \frac{a+c}{2}$. If $\delta_2 = 0$ and $q = 0$, the firm's profit is zero.

In period 1, the firm chooses T and p_1 to maximize Π where $\Pi = \pi((p_1 - c)(a - p_1) + \pi\frac{(a-c)^2}{4})$ if $p_1 q_1 = p_1(a - p_1) \geq T$.

$\Pi = 0$ if $p_1 q_1 = p_1(a - p_1) < T$.

The solution is any T such that $T \leq p_1(a - p_1)$ where $p_1 = \frac{a+c}{2}$. It does not avoid liquidation if demand is zero in period 1 but it optimizes the price policy if demand is positive.

The firm's expected profit equals

$$\Pi = \pi(\frac{(a-c)^2}{4} + \pi\frac{(a-c)^2}{4}) = \frac{\pi(1+\pi)(a-c)^2}{4} \tag{15}$$

The analysis of KIA and equity-based crowdfunding under symmetric information is very similar and is omitted for brevity. The expected entrepreneur's profit equals

$$\frac{\pi(a-c)^2}{2} \tag{16}$$

Also under equity-based crowdfunfing

$$M = \frac{c(a-c)}{2}; \alpha = \frac{c}{\pi(a-c)+c} \tag{17}$$

Lemma 3. *When information is imperfect (demand uncertainty) but symmetric, the firm prefers KIA or equity-based crowdfunding but not AON.*

(16) is not less than (15) because $\pi \leq 1$. If $\delta_1 = 0$, the firm is not able to reach the established threshold under AON so the expected profit under AON is smaller than under KIA or equity-based crowdfunding.

The risk of a failed campaign with some positive probability is unavoidable under AON. Lemma 3 shows that without asymmetric information, one cannot justify the usage of AON.

6.2 Asymmetric information about demand

In this section, asymmetric information exists regarding the quality of a firm's products and services.[22] In particular, we assume that, unlike outside investors, firm owners know the value of parameter a in the demand function.[23] There

some of the points described above and to separate pre-orders and retail in time of delivery (it helps to incorporate feedback in order to improve products for future sales and helps deliver products for funders immediately who need them immediately). Some evidence suggests that the delivery of products to funders starts immediately after the pre-sale campaign is completed (see, for example, https://www.huffingtonpost.com/chris-shuptrine/kickstarter-crowdfunding-_b_9609322.html).

[22] The case where asymmetric information concerns the cost of production does not bring qualitatively different results compared to Section 3.

[23] Note that asymmetric information exists between a firm's owners (founders) and investors (funders). So it directly affects the price of shares in the case of equity-based crowdfunding since it will be based on the funders' beliefs about the firm's type. It also directly affects the pre-sale price in the case of reward-based crowdfunding for the same reason.

are two types of firms: $a = a_h$ for type h and $a = a_l$ for type l, where $a_h > a_l$. Also let us assume that the fraction of type h firms equals x.

The timing of events is as follows:

1. The firm's type is revealed to the entrepreneur.
2. Firm selects financing strategy: KIA, AON or equity-based crowdfunding. If AON is selected, the firm selects T.
3. If equity-based crowdfunding is selected, the firm selects α (fraction of shares) and sells it for an amount M.
4. δ_1 becomes known.
5. Firm selects p_1.
6. If AON is selected and $p_1 q_1 < T$, the firm is liquidated.
7. If KIA or AON and $p_1 q_1 < cq_1$, the firm is liquidated. If equity-based crowdfunding is selected and $M < cq_1$, the firm is liquidated.
8. The market participants update their beliefs about the firm's type.
9. δ_2 becomes known.
10. Firm selects p_2.

Lemma 4. *A separating equilibrium does not exist.*

Proof. See Appendix.

The crucial aspect here is the update of the market's beliefs. Two approaches can be used. The first we can assume that the update of beliefs about the firm follows the normal Baysian rule, which is the case in Lemma 4. Another approach however that is more reasonable in the case of crowdfunding is that after period 2 a lot of information becomes available regarding the product's quality as a result of market's participants' interactions with each other and with the firm so in peirod 2 it is reasonable to assume that the extent of asymmetric information is reduced. In fact without this assumption, the results are quiet "unintereting" as Lemma 4 reveals. However, when the assumption that the market can recognize the product's quality in period 2 is introduced, it makes it harder for a low-quality firm to mimic a high-quality firm in a two-stage model and separation is possible as shown below. Also note that in the previous set-up, the analysis of the pooling equilibrium does not bring new results compared to Secton 4.

The timing of events is as follows:

1. The firm's type is revealed to the entrepreneur.
2. Firm selects financing strategy: KIA, AON or equity-based crowdfunding. If AON is selected, the firm selects T.

3. If equity-based crowdfunding is selected, the firm selects α (fraction of shares) and sells it for an amount M.

4. δ_1 becomes known.

5. Firm selects p_1.

6. If AON is selected and $p_1 q_1 < T$, the firm is liquidated.

7. If KIA or AON and $p_1 q_1 < cq_1$, the firm is liquidated. If equity-based crowdfunding is selected and $M < cq_1$, the firm is liquidated.

8. The firm's type becomes publicly known.

9. δ_2 becomes known.

10. Firm selects p_2.

Proposition 5. *The only separating equilibrium that exists is one where type h selects AON and type l selects KIA or equity-based crowdfunding.*

Proof. See Appendix.

As shown in the Appendix, a separating equilibrium where type h selects AON and type l selects KIA exists if $(\frac{a_l - c}{a_h - c})^2 < \pi < 2 - (\frac{a_h - c}{a_l - c})^2$. The right side of this inequality puts an upper bound on the probability of bankruptcy. The intuition behind this result is as follows. AON is very costly if the probability that the demand is absent is relatively high. In this case the low-quality firm will not mimic the high-quality firm. If, on the contrary, π is very large, the values of (15) and (16) do not differ significantly for the low-quality firm (they are equal in the extreme case when $\pi = 1$) which means that the low-quality firm would mimic the high-quality firm and benefit from the market's optimistic belief about the quality of firms that use AON. The left side of the inequality places a lower bound on the probability of bankruptcy. If, on the contrary, the probability that demand is absent is very high, it would be beneficial for the high-quality firm to not use AON and deviate to KIA or equity-based crowdfunding.

We find that high-quality firms select AON to signal their quality. They do not select equity-based crowdfunding to signal their quality. This is consistent with the pecking-order theory by Myers and Majluf (1984).

Next we analyze pooling equilibria.

Proposition 6. *1) If x is large enough, there exists a pooling equilibrium with KIA; 2) mispricing is larger under a pooling equilibrium with AON than under a pooling equilibrium with KIA; 3) If x is large enough then the mispricing is smaller under a pooling equilibrium with KIA than under a pooling equilibrium with equity-based crowdfunding; 3) If x is large enough then the payoff of h in a pooling equilibrium with KIA is greater than that in a separating equilibrium where h plays AON.*

Proof. See Appendix.

In Proposition 6 we find that pooling with KIA prevails if the fraction of high-quality firms is high enough so we can conclude that reward-based crowdfunding

is pro-cyclical. Intuitively, if x is high enough, the mispricing of h is smaller in a pooling equilibrium and there are less incentives to prefer a separating equilibrium.

7 The model extensions and robustness

7.1 An extension with fixed costs

Suppose that the fixed costs of launching production equals $I > 0$. The crowdfunding campaign needs to then cover both fixed and variable costs of production. The analysis of this extension does not bring any significantly new results except Lemma 5 below for a two-period model. In period $t = 1, 2$, if the firm produces q_t units, it costs $I + cq_t$ in total. The demand equals $q_t = a - p_t$. Under reward-based crowdfunding the firm collects pre-orders for period 1. Under equity-based crowdfunding, the firm sells a fraction α of the firm.

Lemma 5. *If I is sufficiently small ($\frac{(a-c)^2}{4} \geq I$), the firm is indifferent between reward-based and equity-based crowdfunding. If I is large, equity-based crowdfunding is preferred.*

Proof. See Appendix.

Lemma 5 indicates the difference between the long-term character of earnings in the case of equity-based crowdfunding and short-term earnings in the case of reward-based crowdfunding. Large projects (high fixed costs I and high variable costs c), in most cases, prefer equity-based crowdfunding. It is not because of the presence of financial market imperfections but because of "technical" reasons. Equity-based crowdfunding has more flexibility since funders can count on long-term firm profits. As was mentioned previously, this result in Belleflamme et al (2014) is due primarily from assumptions about community benefits in period 1 when the firm conducts the crowdfunding. These benefits differ among funders in the case of a reward-based campaign so the small size of crowdfunding captures these differences with a high advantage for the firm, while in the equity-based case community benefits are more common so there is no advantage of having a small scale. As follows from Paakkarinen (2016), equity-based campaigns are much larger than reward-based campaigns but firms select equity-based campaigns mostly for the possibility of collecting a large amount of capital and not to select a better price discrimination approach.

7.2 Other Extensions

Different demand functions. Our focus in this article is to analyze the role of different market imperfections in crowdfunding. That is why we adopt a relatively simple demand function. In dynamic monopoly pricing literature this approach is not unusual (see, for example, Demichelis and Tarola (2006)). Most of our results (such as Propositions 1, 2 etc.) are intuitively sound and will hold if different demand functions are used. Alternatively, a sigificantly different approach of modelling the demand side can be taken where individual customers

with different demand functions are included (see, for example, Belleflamme et al (2014) and Hu, Li and Shi (2014)). This approach is often used in industrial organization or price discrimination literature. Our focus is on market imperfections and financial aspects of crowdfunding and the approach that uses total demand functions from investors/funders (the market) is very common.

Case with continuous demand shock. When considering demand uncertainty we usually assumed that δ (demand "shock") has only two values: 0 or 1. In other words, managers receive an "extreme" signal: either demand is "normal" or it is completely non-existant. In such a case there is no role for the value of T as a signalling device. If $\delta = 0$, T does not have any importance and if $\delta = 1$, the type h does not have too much choice in terms of T selection. Now assume that the demand is as follows: $q = \delta(a - p)$, where δ is uniformly distributed on $[0, 1]$. Here again we find that when information between founders and funders is symmetric, the firm's expected profit earnings are lower when AON is used than when KIA or equity-based crowdfunding is used. It is similar to the result in Section 6.1. If δ is large, the firm's profit is the same under every type of crowdfunding. If δ is small, the firm is not able to reach the established threshold under AON so the expected profit under AON is smaller than under KIA or equity-based crowdfunding.

For the case with asymmetric information we found the following.

Proposition 7. *If T is very large or very low a separating equilibrium does not exist. Otherwise, a separating equilibrium exists, where type h selects AON and type l selects KIA or equity-based crowdfunding.*

Proof. Ommitted for brevity.

The intuition behind this result is as follows. AON is more attractive when the required campaign threshold is smaller since it reduces the risk that the crowdfunding campaign will fail. So if this risk is very small the low-quality firm will mimick the high-quality firm. On the other hand, if the risk that the crowdfunding campaign fails is very high, it is beneficial for the high-quality firm to not use AON and deviate to KIA.[24]

Different types of moral hazard. In our model (Section 3), entrepreneurial moral hazard takes place because the entrepreneur's equity stake in the firm is reduced while his individual effort is costly and this cost is not shared. This approach is very common in financing literature (starting with Jensen and Meckling (1976)) and typically creates an agency cost of equity financing as in our paper. There are many different ways to analyze moral hazard issues, for example, to explicitely model the entrepreneur's level of effort. This approach is quite common in contract literature. In finance literature this approach was used, for example, in Innes (1991). The analysis in this paper revealed the advantage of debt financing over equity financing, which is consistent with the spirit of our modelling where equity-based crowdfunding has a disadvantage due to entrepreneurial moral hazard.

[24] Chakraborty an Swinney (2017) find that a higher T can be used as a signalling device by high-quality firms. They focus on AON. We find that the relationship between a firm's quality and the campaign goal is non-linear. More discussion is provided in Section 9.

The distribution of types. In sections 4 and 6, which deal with asymmetric information we use two types of firms to illustrate the main ideas. This is also very typical in literature. A natural question though is whether the results stand if one considers a case with multiple types. Our analysis shows[25] that most conclusions remain the same: under asymmetric information, equity-based crowdfunding is an inferior choice compared to reward-based crowdfunding. In the case of multiple types, however, one may have a semi-separating or even pooling equilibrium where only the type with the highest cost (speaking about Section 4) will be indifferent between the two types of crowdfunding and all other types select reward-based crowdfunding. In Section 5, our analysis shows that the results may hold even in a multiple types environment though more research is required. The main implication of our analysis holds. In particular, our results show that there is no semi-separating equlibrium where the average quality of types that choose equity-based crowdfunding or the KIA method is higher than those that choose AON, which is consistent with our basic model.

Mixed financing and more types of financing. Unlike capital structure literature, where debt/equity mix is a very common strategy (as opposed to pure equity or pure debt financing), simultaneously conducting different kinds of crowdfunding is not common. Nevertheless, if mixed financing is allowed in period 1, most results will stand. For example, if mixing bank debt and crowdfunding is allowed in period 1, as in Section 2, the results stand though the condition (1) can be softened for a firm if it uses equity-based crowdfunding. Similarly, Proposition 1 stands qualitatively but the formulas will be quantitaively different. In Sections 4 and 6, a signalling equilibrium may still exist where a high-quality firm uses a mix of reward-based crowdfunding and a bank loan or a mix of a bank loan and AON, as in Section 6, although restricting conditions will change quantitatively. Introducing additional financing strategies such as debt-based crowdfunding is an interesting direction. Most results regarding the costs and benefits of different financing strategies found in this paper are quite general and do not depend on the introduction of additional options into the model.[26] Quantitatively though, some conditions may change. It is definitely an interesting direction for future research. Note that most existing theoretical literature on crowdfunding often considers reward-based and equity-based crowdfunding separately from debt-based crowdfunding. One of the reasons for this seems to be that the founders' objectives are quite different in these scenarios (see, for example, Hildebrand, Puri, and Rocholl (2014)).

[25] Proofs are available upon demand. Note that the calculations become much longer and technically more complicated, which is very typical for multiple type games with asymmetric information.

[26] We have analyzed a model's variation that included the possibility of using debt-based crowdfunding. Under debt-based crowdfunding, the firm promises to return inital investments from funders with interest. We found that the main results of the model are not affected. Some slight differences exist. For example, when debt is risk-free (which can be the case without demand uncertainty) debt-based crowdfunding can be used as a signalling tool along with reward-based crowdfunding. However, in a more realistic scenario when demand is uncertain and debt is risky, the main result stands that favors reward-based crowdfunding. The same holds for the modelling moral hazard.

8 Hybrid cases

Ideally, the next step would be to analyze the optimal financing policy when many factors such as asymmetric information, moral hazard, market feedback etc. are present in the model simultaneusly. This is an intriguing challenge for future research. One should say that the creation of such a universal global model is technically difficult and in many cases may not bring many analytical and intuitively sound results.[27] This section provides an example of such an analysis.

Case 1. Consider the situation where firms have private information about production costs (Section 4). In this situation reward-based crowdfunding can be used as a signal of a firm's quality. Now suppose that a firm is terminated (bankrputcy occurs) in period 1, if the firm is not able to deliver its product to customers and the firm uses reward-based crowdfunding (similar to the ideas from sections 5 and 6). Gabison (2015) noted[28] that eventhough there is no formal regulation of reward-based crowdfunding in most countries, in most cases consumers (funders) are under the consumer protection law (which exists in most developed countries) and therefore a violation of this law can be costly for the firm. As in Section 4, c is either equal to c_l or c_h and $c_l < c_h$. Like in Section 5, the production output is stochastic in period 1 and depends on parameter Q (similar to stochastic demand in Section 6): $Q = 1$ with probability γ or 0 with probability $1 - \gamma$. Bankruptcy only occurs when $Q = 0$ and the firm uses reward-based crowdfunding. Bankruptcy does not occur as a result of failed production in period 1 under equity-based crowdfunding since by its nature no promises are made to funders/investors and dividends are not guaranteed.

The timing of events is as follows:

1. The firm's type is revealed to the entrepreneur.

2. Firm selects financing strategy: reward-based crowdfunding or equity-based crowdfunding.

[27] A good example is capital structure theory. Most of the intuition published in textbooks for the last 50 years is based on models that consider each factor separately (pecking order theory for asymmetric inofrmation, trade-off thoery for taxes and bankruptcy costs etc.). For an example of capital structure theory review and the role of market imperfections see Harris and Raviv (1991), Miglo (2011) and Miglo (2016). Models combining several factors are much less popular and much more technically complicated though some researchers suggest that these types of models are a prominnet direction for future research. Also note that based on managers' surveys, managers only support around 50% (see, for example, Graham and Harvey (2001)) of basic theories, which means that the precentage of managers that use even more complicated ideas is even smaller. Crowdfunding theory is a much younger theory than capital structure theory so it is in the stage of its development where the quality and relative simplicity of its basic ideas are probably the most important objectives of its research along with managerial education on these ideas (see, for example, Loane, Ramsey and Ibbotson (2016)).

[28] See also Ibrahim (2016) and Moores (2015) for a legal environment analysis regarding reward-based crowdfunding. Mollick (2015) empirically analyzes the percentage of failed firms that used reward-based crowdfunding.

3. If equity-based crowdfunding is selected, α is determined and the firm sells it for price M.

4. Firm selects p_1.

5. If equity-based crowdfunding is selected and $M < cq_1$, the firm is liquidated. If reward-based crowdfunding is selected and $p_1 q_1 < cq_1$, the firm is liquidated.

6. Q becomes known. If $Q = 0$ and reward-based crowdfunding was selected, the firm goes bankrupt.

7. Firm selects p_2.

An equilibrium is defined as a situation where no firm type has the incentive to deviate. Like in Section 4, since information only concerns the production cost and not the demand side, the informational game will only affect the equity-crowdfunding scenario.

Proposition 8. *If* $\frac{a-c_l}{a-c_h} < 2$, *a separating equilibrium does not exist. Otherwise, if* γ *is sufficiently large, the only efficient separating equilibrium that exists is one where type* l *selects reward-based crowdfunding and type* h *selects equity-based crowdfunding.*

Proof. See Appendix.

To explain the results of this proposition, note that Section 4 found that high-quality firms can use reward-based crowdfunding to signal their quality. That section did not consider a potential cost of reward-based crowdfunding related to bankruptcy in the case when the firm is not able to deliver their product in period 1. This case asks if the result stands if such a cost is taken into consideration. What we found is that the result stands but there are cases when a separating equilibrium where a high-quality firm uses reward-based crowdfuning does not exist. The meaning of the condition stated in the proposition is that if the difference between the firm types is sufficiently small, such an equilibrium may not exist. Secondly and more interestingly is that if the probability of bankruptcy is sufficiently small, an equilibrium may not exist. In this case, a low-quality firm may still be interested in mimicking a high-quality type when the latter choses reward-based crowdfunding.

Case 2. Similar to some previous sections, this case considers a model with imperfect information. However, here we assume that crowdfunding helps the firm obtain information about demand. Suppose that if the firm uses crowdfunding, it can improve the product's quality after obtaining useful information about demand in period 1: more specifically, in period 2 the demand becomes $q = sa - p, s \geq 1$.[29] We assume that s has different values for different types of crowdfunding: $s \in \{s_r, s_e\}, s_r > s_e$ where s_r is the product improvement if reward-based crowdfunding is used. $s_r > s_e$ because under reward-based

[29] Xu, Yang, Rao, Fu, Huang, and Bailey (2014), Block, Hornuf and Moritz (2016) and da Cruz (2016) empiricaly analyze different aspects of the informational value of crowdfunding for entrepreneurs.

crowdfunding, the funders know that the firm's launch of production and, respectively, its survival depend on their pre-orders and the firm's response to this feedback is expected to be very efficient since the firm's survival depends on it.[30] Also, under reward-based crowdfunding, the funders have a short-term interaction with the firm whereas under equity-based crowdfunding, these interactions are long-term. So the former incentivizes the funders to provide more intense feedback. If the firm uses traditional financing like a bank loan, for example, it does not get the same feedback as it would with crowdfunding and the demand does not change in period 2. On the other hand, as in Section 5, banks have a better ability to monitor and control the entrepreneurs.[31] We assume that the manager has some private benefits b when using crowdfunding.

The timing of events is as follows:

1. Firm selects a financing strategy: bank loan, reward-based crowdfunding or equity-based crowdfunding.

2. If equity-based crowdfunding is selected, the firm chooses α (the fraction of the firm for sale) and sells it for price M. If $M < cq_1$, the firm is liquidated.

3. Firm selects p_1. The demand for the product is determined.

4. Firm selects p_2. The demand for the product is determined.

Proposition 9. *The firm takes a bank loan if s_r is sufficiently small or b is sufficiently large. Otherwise, the firm selects reward-based crowdfunding. Prices are higher and quantity produced is lower under crowdfunding. Crowdfunding is selected over a traditional bank loan if a is either very small or very large. For medium levels of a, a bank loan is preferred.*

Proof. See Appendix.

It is shown in the Appendix that the entrepreneur's profits under the different strategies are equal to the following.

$$\Pi_r = \frac{(a-b-c)^2}{4} + \frac{(s_r a - b - c)^2}{4} - I$$

$$\Pi_e = \frac{(a-b-c)^2}{4} + \frac{(s_e a - b - c)^2}{4} - I$$

[30] Note that market feedback represents probably the most important community benefit of crowdfunding for the firm (because it may increase its product quality and repsectively their future profits) as well as for funders and customers who can enjoy higher quality products as a result of market feedback. Note also that we explicity model this mechanism in our model through providing better information to the firm in period 1, which allows them to improve their product's quality in period 2 etc. Belleflamme et al (2014) assume that there are some exogenously given community benefits in period 1 as a result of crowdfunding. As was mentioned previously, Cholakova and Bart (2015) find that non-monetary benefits do not play a singificant role for funders.

[31] Other traditional forms of entrepreneurial financing such as venture capital financing also have a high degree of monitoring so the model can be applied to those cases as well.

$$\Pi_b = \frac{(a-c)^2}{2} - I$$

where subscript r stands for reward-based crowdfunding, e means equity-based crowdfunding and b means bank loan.

The firm is indifferent between reward-based crowdfunding and a bank loan if

$$\frac{(a-b-c)^2}{2} + \frac{(s_r a - b - c)^2}{2} = (a-c)^2 \tag{18}$$

The firm is indifferent between equity-based crowdfunding and a bank loan if

$$\frac{(a-b-c)^2}{2} + \frac{(s_e a - b - c)^2}{2} = (a-c)^2 \tag{19}$$

Also if

$$(a-c-b)^2 < 4I \tag{20}$$

the firm will not be able to use reward-based crowdfunding. And if $(a-c-b)^2 \geq 4I$, the firm prefers reward-based crowdfunding over equity-based crowdfunding.

Figure 1 illustrates the equilibrium decision-making for the entrepreneurs. The lines represent equations (18), (19) and (20). Letters RC, EC and B denote the areas where the entrepreneurs choose reward-based crowdfunding, equity-based crowdfunding, and a bank loan respectively.

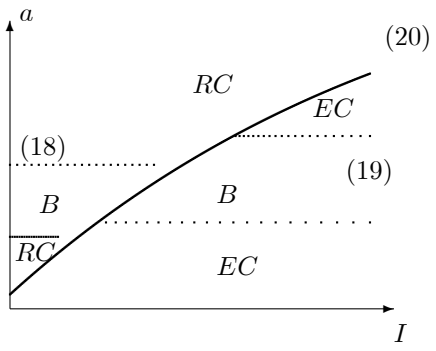

Figure 1. The choice of financing in "Hybrid" case 2 (market feedback, bank monitoring). Letters RC, EC and B denote the areas where the entrepreneurs choose reward-based crowdfunding, equity-based crowdfunding, and a bank loan respectively.

As follows from Figure 1, firms that use crowdfunding are either projects with very small demand or very high demand. Also, entrepreneurs with EC have a higher I for any value of a compared to entrepreneurs with RC. Overall we can see that firms with a medium level of demand prefer B, firms with

stronger demand prefer crowdfunding, firms with a large amount of investments and strong demand or very weak demand prefer EC and firms with smaller investments and strong demand or very weak demand prefer RC.

9 Implications

Our paper has several implications for an entrepreneurial firm's choice of financing.

Propositions 3 and 6 find that asymmetric information favors reward-based crowdfunding. Also Proposition 2, 5 and 7 imply that when asymmetric information is important, high-quality projects prefer reward-based crowdfunding. As was mentioned previously, this is contradictory, to some extent, to the spirit of the results in Belleflamme et al (2014), which finds that asymmetric information favors equity-based crowdfunding.[32] In our model, equity-based crowdfunding suffers more from asymmetric information, which is consistent with the spirit of the majority of finance literature where equity-financing is generally the most sensitive to the asymmetric information problem. Equity-based crowdfunding cannot be used as a signalling tool by a high-quality firm since it will always be mimicked by a low-quality firm as the share price of a high-quality firm is always higher than that of a low-quality firm. In contrast, a high-quality firm can use reward-based crowdfunding. This is because a low-quality firm may find it unproftable to mimick this strategy as it will be taking more risk to achieve its threshold. This prediction has not been directly tested but is consistent with the spirit of the results found in Ahlers, Cumming, Guenther, and Schweizer (2015) and Mollick (2014) (that the firm's financing choice can serve as a signal of a project's quality). Furthermore, the entrepreneur's larger fraction of equity is associated with a higher project quality. In our case, reward-based crowdfunding implies a higher fraction of ownership held by the entrepreneur. Ahlers et al (2015) examine the effectiveness of the signals used by entrepreneurs to induce (small) investors to commit financial resources in an equity-based crowdfunding context. They found that retaining equity is an effective signal and can therefore strongly impact the probability of a funding's success. It is consistent with the spirit of our result that reward-based crowdfunding may be preferred by entrepreneurs of higher quality.

Propositions 5 and 7 imply that high-quality projects may prefer AON over KIA. This is consistent with the spirit of Cumming, Leboeuf and Schwienbacher (2014). They show that KIA campaigns are less successful in meeting their fundraising goals. Also, note that the rate of success of campaigns on

[32] For example, it is well-known in capital structure theory that asymmetric information damages equity financing more than debt financing and that equity financing can not be used by a high-quality type as a signal of quality whereas in some cases debt financing can be used (Leland and Pyle (1977)). So applying this example to Belleflamme et al (2014), who claim that asymmetric information is more damaging for reward-based crowdfunding, it would be no surprise to find that a separating equilibrium where a high-quality firm uses reward-based crowdfunding does not exist or that there is a separating equilibrium where the high-quality firm uses equity-based crowdfunding.

Kickstarter, which only uses AON, is higher than on Indiegogo.[33] Proposition 7 suggests that the high-qulity firm can select the threshold level as a signalling device. Interestingly the result is that it should neither be very low or very high. To some extent it is consistent with the spirit of the results in some papers in that higher targets do not necessarily signal a better quality. For example, Mollick (2014) and Cordova et al (2015) found that setting higher thresholds does not lead to higher camapign rates of success. Further research is required.

Proposition 1 and 4 imply that pricing and production strategies are affected by moral hazard issues and the costs of financial distress. In particular, prices can be higher and quantity produced can be lower under equity-based crowdfunding. This is consistent with Paakkarinen (2016) that noted that in contrast to reward-based crowdfunding, equity-based crowdfunding may have fewer customers, but higher margins. More broadly, the point that moral hazard issues related to the entrepreneurial cost of effort and the reduced equity stake are more important under equity-based crowdfunding is consistent with Gabison (2015) and Paakkarinen (2016), which noted that equity-based crowdfunding is much more constricted in comparison to other forms of crowdfunding.

As follows from Moores (2015), the bankruptcy procedure is not clearly defined in the case of a failed crowdfunding campaign, in fact, the firm may not even be declared bankrupt even though consumers are under the customer protection law (at least in the case of reward-based crowdfunding). As noted in Moores (2015), further development and clarifications in this area are helpful. Our analysis suggests that from a policy perspective higher bankruptcy costs are benefitial for the exsitence of separating equilibria where high-quality firms can use reward-based crowdfunding to singal their quality and avoid being mimicked by low-quality firms.

As follows from Lemma 2 and Proposition 6, firms should avoid crowdfunding if moral hazard considerations related to the weak ability of funders to monitor the firm (compared to traditional financing from bank loans or venture capital financing) are very important. These results are consistent with Xu (2017), which finds that entrepreneurs switch between crowdfunding an bank borrowing depending on the relative costs of financing. Perhaps more interestingly is that if we only consider reward-based crowdfunding vs. bank financing (the area above line (20) in Figure 1), projects with high I and high a, i.e potentially high risk, high investment (novelty) and potentially high demand (a) will prefer crowdfunding vs. bank financing. This is also consistent with Xu (2017). Also we find that firms should use crowdfunding for projects with either a very small demand or a very high demand. Firms that use equity-based crowdfunding have a higher amount of fixed costs compared to entrepreneurs with reward-based crowdfunding. Finally as suggested in Proposition 4, the link between the firm's quality (probability of bankruptcy) and the choice between financing strategies is not linear. For example, a bank loan should be selected over crowdfunding if this probability is either very low or very high. As was

[33] See, for example:
http://crowdfunding.cmf-fmc.ca/facts_and_stats/how-likely-is-your-crowdfunding-campaign-to-succeed

mentioned previously, this is in contrast to Chemla and Tinn (2017). They found that lower performance/higher magnitude of production cost (variable cost) makes it less likely for the firm to select crowdfunding.

Finally note that Proposition 6 suggested that KIA is procyclical. As far as we know no empirical research exists testing this prediction directly. Further research is expected. Interestingly, Zhang, Datta and Kannan (2017) find that crowdfunding can be seen as a substitute to bank loans in terms of overall dynamics. Previous literature found that debt financing is countercyclical (Choe, Masulis and Nanda (1993)). Note also the famous negative correlation between debt and profitability (Titman and Wessels (1988)) so the result in Zhang, Datta and Kannan (2017) is indirectly consistent with our prediction.

The results of our analysis are summarized in Table 2.

Table 2. Market imperfections and the model's results.

Market imperfection(s)	*Results*
Asymmetric information about production cost	Good quality projects prefer reward-based crowdfunding
Entrepreneur's moral hazard due to his reduced equity stake	Firms prefer reward-based crowdfunding. Prices are higher and quatity produced is lower under equity-based crowdfunding
Asymmetric information about demand	"Signalling by risk-bearing". Low-quality firm selects KIA or equity-based crowdfunding and the high-quality firm selects AON. KIA is counter-cyclical
Bankruptcy costs vs. bank monitoring case 1	Prices are higher and quantity produced is lower under crowdfunding than under a bank loan; crowdfunding is selected over a bank loan when private benefits are low, the demand is low and the probability of bankruptcy is high
Asymmetric information with continuous demand shock	Signlling with AON: the threshold should neither be very small nor very large
Bankruptcy costs vs. bank monitoring case 2	Non-linear relationship between the probability of bankruptcy and the project's quality and the choice between crowdfunding and a bank loan
Hybrid case 1 (asymmetric information about demand and bankruptcy costs)	If bankrupcy costs are high, firms use reward-based crowdfunding to signal their quality

Market imperfection(s)	*Results*
Hybrid case 2 (market feedback, bank monitoring)	Prices are higher and quantity produced is lower under crowdfunding. Crowdfunding is selected over a traditional bank loan if demand is either very small or very large.

10 Conclusions

This paper is the first one that considers the choice between AON, KIA and equity-based crowdfunding under different types of market imperfections using a new approach with the demand side. The closest one is Belleflamme et al (2014) that analyses AON and equity-based crowdfunding under asymmetric information but uses a different demand approach and some other special features such as non-monetary ad-hoc benefits etc. The main innovation in terms of methods used and the paper's contribution lies with asymmetric information. However, the paper is structured in such a way that other market imperfections are analysed as well. The structure of the model is quite simple and allows for that. For example, we obtain several interesting results with regard to moral hazard. Existing theoretical literature on crowdfunding has extensively focused on such features of crowdfunding as price discrimination. This paper focuses on information aspects of crowdfunding, which is more in the spirit of finance literature than industrial organization literature. In addition to traditional forms of markets imperfections (asymmetric information, moral hazard, bankruptcy costs etc.) our model includes some other features of crowdfunding such as market feedback. Another contribution to exisitng literature is that we analyze a dynamic (two-period) model of crowdfunding. Most existing theoretical papers on crowdfunding consider static models. The presence of two production periods allows us to capture an essential difference between reward-based and equity-based crowdfunding: under equity-based crowdfunding funders can count on long-term firm profits.

The model provides several implications, most of which have not yet been tested. When asymmetric information is important, high-quality projects prefer reward-based crowdfunding. This is opposite, to some extent, to the spirit of the results in Belleflamme et al (2014), which finds that asymmetric information favors equity-based crowdfunding. Also, we find that the choice of the all-or-nothing mechanism as opposed to keep-it-all can serve as a signal of a firm's quality. Among other findings note the following. Prices can be higher and quantity produced can be lower under equity-based crowdfunding than under reward-based crowdfunding due to distortions created by moral hazard problems relarted to the cost of entrepreneurial effort. Firms should avoid crowdfunding if moral hazard considerations related to the weak ability of funders to monitor the firm (compared to traditional financing from bank loans or venture capital financing) are very important. The link between the firm's quality (probability

of bankruptcy) and the choice between financing strategies is not linear. For example, a bank loan should be selected over crowdfunding if this probability is either very low or very high. This is in contrast to Chemla and Tinn (2017). They found that lower performance/higher production cost (variable cost) makes it less likely for the firm to select crowdfunding.

Appendix

Proof of Proposition 1. After shares are sold, the firm chooses p (correspondingly $q = a - p$) to maximize

$$(1-\alpha)(p(a-p) + M - cq) - e(a-p) \tag{21}$$

subject to $M \geq cq$. Two cases are possible. If $\frac{a+c+e/(1-\alpha)}{2} \geq a - \frac{M}{c}$ we have $p = \frac{a+c+e/(1-\alpha)}{2}$. Otherwise we have a corner solution $p = \frac{ca-M}{c}$. In both cases, under the optimal strategy chosen by the firm $M = cq$.

The funders anticipate this and therefore M and α will be connected as follows:

$$M = \alpha p(a-p) = c(a-p) \tag{22}$$

Then we have:

$$\alpha = \frac{M}{p(a-p)} = \frac{c(a-p)}{p(a-p)} = \frac{c}{p}$$

Substituting this into (21) we get that the entrepreneur‘s expected profit is equal to:

$$(p-c-e)(a-p) \tag{23}$$

In the beginning, the entrepreneur selects α to maximize (23). The case where $\frac{a+c+e/(1-\alpha)}{2} < a - \frac{M}{c}$ is not optimal. The firm should increase M and α becasue of the following. (23) is concave in p and $p = \frac{a+c+e}{2}$ is an optimal p in (23). Further $p = \frac{a+c+e/(1-\alpha)}{2}$ is closer to the optimum than $p = \frac{ca-M}{c}$. So we have $p = \frac{a+c+e/(1-\alpha)}{2}$.

Using the above formula for p, (23) can be converted into

$$\frac{(a-c)^2}{4} - \frac{e^2}{4(1-\alpha)^2} + \frac{e^2}{2(1-\alpha)} - \frac{ea}{2} + \frac{ec}{2} \tag{24}$$

If $\alpha = 0$, (24) will be equal to $\frac{(a-c-e)^2}{4}$. This is the same value that we under a reward-based crowdfunding scenario. When α is positive, the entrepreneur‘s profit under equity crowdfunding will be smaller since the derivative of (24) in α is negative.

Proof of Proposition 2. Consider a situation where l selects reward-based crowdfunding and h selects equity-based crowdfunding. We have (all calculations are based on the symmetric information case for each type described in Section 2):

$$\Pi_h = \frac{(a-c_h)^2}{4} \tag{25}$$

$$\Pi_l = \frac{(a-c_l)^2}{4}$$

where Π_j is the equilibrium profit of type j. Also we have (as follows from Lemma 1):

$$\alpha_h = \frac{4M_h}{(a-c_h)^2+4M_h}; M_h \geq \frac{c_h(a-c_h)}{2}$$

We will assume $M_h = \frac{c_h(a-c_h)}{2}$. The proof is similar for any value of M_h. For simplicity we assume that M_h has the lowest value from the range of possible values. It can also be justified if moral hazard is present (as described in Section 3 or 5) and therefore minimizing M_h mitigates the extent of moral hazard problems. Note that

$$\alpha_h = \frac{2c_h}{a+c_h} \tag{26}$$

h does not have an incentive to mimick l since, as mentioned above, in this section asymmetric information does not concern reward-based crowdfunding. So if h chose reward-based crowdfunding it would have the same payoff as it would in equilibrium: $\frac{(a-c_h)^2}{4}$. Now suppose that l mimics h and chooses equity-based crowdfunding instead. l's profit Π_{lh} then equals

$$\Pi_{lh} = (1-\alpha_h)(pq + M_h - c_l q) \tag{27}$$

In this equation p and q are discussed below. Note that when l mimicks h, it has to sell a larger stake of equity in the firm compared to the symmetric information case. Indeed if l sells equity under symmetric information we have

$$\alpha_l = \frac{2c_l}{a+c_l}$$

This is smaller than (26) because $c_l < c_h$. Note that the amount of funds raised will also be different than under symmetric information.

Two cases are possible. First,

$$\frac{c_h(a-c_h)}{2} > \frac{c_l(a-c_l)}{2} \tag{28}$$

The left side of this condition shows the cost of production by type h under symmetric information and the right side shows that for type l. If (28) holds, l will be able to raise enough funds to produce an optimal quantity of goods. Indeed the choice of p is determined by maximizing (27) under the condition that

$$M_h \geq c_l q \tag{29}$$

Absolute maximum is $p = \frac{a+c_l}{2}$ and if condition (28) holds, the constraint (29) will not be binded. Then $\Pi_{lh} = (1-\frac{2c_h}{a+c_h})((\frac{a+c_l}{2}-c_l)(a-\frac{a+c_l}{2})+c_h(\frac{a-c_h}{2}))$. After simplifications we find that this is less than $\frac{(a-c_l)^2}{4}$ when $c_h^2 - c_l^2 < 2a(c_h - c_l)$. This holds because $c_l < c_h < a$. So l will not mimick h.

Second case is when (28) does not hold. In this case l is not able to produce the quantity that would be optimal under symmetric information. Two situations are possible. 1. $M_h = c_l q$. Then:

$$q = \frac{M_h}{c_l} = \frac{c_h(a - p_h)}{c_l}$$

Since $p_h = \frac{a+c_h}{2}$, this equals $\frac{c_h(a-c_h)}{2c_l}$. The entrepreneur's profit then equals $\Pi_{lh} = (1 - \frac{2c_h}{a+c_h})(a - \frac{c_h(a-c_h)}{2c_l})\frac{c_h(a-c_h)}{2c_l}$. This is less than $\frac{(a-c_l)^2}{4}$ because (28) does not hold and $c_l < c_h$. Indeed the inequality $\Pi_{lh} < \frac{(a-c_l)^2}{4}$ can be written as $c_h^2(a-c_h)^2(2ac_l - ac_h + c_h^2) < (a-c_l)^2 c_l^2 c_h(a+c_h)$. Here $c_h^2(a-c_h)^2 < (a-c_l)^2 c_l^2$ because (28) does not hold and $2ac_l - ac_h + c_h^2 < c_h(a + c_h)$ because $c_l < c_h$.

2. $M_h > c_l q$. This is only possible if $p \leq c_l$. Otherwise it makes no sense to keep unused cash because the production of extra unitis brings profit. In this case the firm's profit equals: $(1 - \frac{2c_h}{a+c_h})c_h(\frac{a-c_h}{2})$. This is less than $\frac{(a-c_l)^2}{4}$ because $c_l < c_h$.

Therefore l will not mimick h.

Now consider a situation where h selects reward-based crowdfunding and l selects equity-based crowdfunding. Suppose that h mimics l and chooses equity-based crowdfunding instead. Using similar reasoning one can show that h's profit Π_{hl} equals

$$\Pi_{hl} = (1 - \frac{c_l}{a})(a - \frac{c_l(a-c_l)}{2c_h})\frac{c_l(a-c_l)}{2c_h}$$

This is greater than (25) because $c_l < c_h$. Therefore h will mimick l. This means that such an equilibrium does not exist.

Proof of Proposition 3. Consider a pooling equilibrium where both types select reward-based crowdfunding, which is supported by off-equilibrium market beliefs that the firm is h if the market participants observe equity-based crowdfunding. First of all, let us verify non-deviation for each type to equity-based crowdfunding. Since under pooling with reward-based crowdfunding l's payoff is the same as in the separating equilibrium in Proposition 2, it follows from the proof of Proposition 2 that l does not deviate. h does not deviate because it gets the same amount as in equilibrium.

Let us now verify that off-equilibrium beliefs survive the intuitive criterion of Cho and Kreps (1987). To show this, let us calculate the maximal payoff of type h in the case that it plays equity-based crowdfunding. Its payoff is evidently maximized if the market's beliefs place the probability 1 on type l observing equity. If off-equilibrium beliefs survive the intuitive criterion, this expression must be not less than the payoff of h in equilibrium.[34] It follows from our analysis of the separating equilubrium above that the payoff of h will be higher than its equilibtum payoff if the market places the probbaility of 1 on type l.

[34] Otherwise the market should place the probability 0 that h deviates to equity.

Proof of Lemma 2. Consider crowdfunding. After the shares are sold, the firm chooses p to maximize $(1-\alpha)(\gamma p(a-p)+M-(c+b)q)$ subject to

$$M \geq (c+b)q \tag{30}$$

.It implies:

$$p = \frac{a+(c+b)/\gamma}{2} \tag{31}$$

The firm's expected profit is $\gamma p(a-p) = \gamma\frac{(a+(c+b)/\gamma)(a-(c+b)/\gamma)}{4}$. The funders' expected earnings should cover their investment cost or:

$$\alpha(\gamma\frac{(a+(c+b)/\gamma)(a-(c+b)/\gamma)}{4}) \geq M \tag{32}$$

Under the optimal solution the conditions (30) and (32) will be binded because the firm can always make α as small as necessary to satisfy them. Then we have:

$$\alpha = \frac{(c+b)q}{\gamma\frac{(a+(c+b)/\gamma)(a-(c+b)/\gamma)}{4}} = \frac{2(c+b)}{\gamma a+c+b}$$

The entrepreneur's expected profit equals:

$$(1-\frac{2(c+b)}{\gamma a+c+b})(\gamma\frac{(a+(c+b)/\gamma)(a-(c+b)/\gamma)}{4}) = \frac{(\gamma a-c-b)^2}{4\gamma} \tag{33}$$

Consider bank loan financing. The firm maximizes $\gamma(p(a-p)-F)-(1-\gamma)B-c(a-p)$ subject to: $pq = p(a-p) \geq cq = c(a-p)$. F is the face value of debt.

The solution gives us

$$p = \frac{a+c/\gamma}{2} \tag{34}$$

The comparison of (31) and (34) leads to the first part of Lemma 2.

The banker's expected payoff equals: $\gamma F = c(a-p) = c(a-\frac{a+c/\gamma}{2}) = c\frac{a-c/\gamma}{2}$. It implies $F = \frac{c(\gamma a-c)}{2\gamma^2}$.

The firm's profit equals

$$\Pi = \frac{\gamma(a-c/\gamma)^2}{4} = \frac{(\gamma a-c)^2}{4\gamma} - (1-\gamma)B \tag{35}$$

The comparison of (33) and (35) leads to the second part part of Lemma 2.

Proof of Proposition 4. Consider crowdfunding. After the shares are sold, the entrepreneur decides whether to run away or start the production. If he decides to start the production, the firm chooses p to maximize $(1-\alpha)(\gamma p(a-p)+M-cq)$ subject to

$$M \geq cq \tag{36}$$

It implies:

$$p = \frac{a+c/\gamma}{2} \tag{37}$$

The firm's expected profit is $\gamma p(a-p) = \gamma\frac{(a+c/\gamma)(a-c/\gamma)}{4}$. The funders' expected earnings should cover their investment cost or:

$$\alpha(\gamma\frac{(a+c/\gamma)(a-c/\gamma)}{4}) \geq M \tag{38}$$

Under the optimal solution the conditions (36) and (38) will be binded because the firm can always make α as small as necessary to satisfy them. Then we have:

$$\alpha = \frac{cq}{\gamma\frac{(a+c/\gamma)(a-c/\gamma)}{4}} = \frac{2c}{\gamma a + c}$$

The entrepreneur's expected profit equals:

$$(1 - \frac{2c}{\gamma a + c})(\gamma\frac{(a+c/\gamma)(a-c/\gamma)}{4}) = \frac{(\gamma a - c)^2}{4\gamma} \tag{39}$$

If the entrepreneur decides to run away, his profit is equal to $M = cq = c(a - \frac{a+c/\gamma}{2}) = c\frac{a-c/\gamma}{2}$. This is not greater than (33) if

$$c \leq \frac{\gamma a}{3} \tag{40}$$

Consider bank loan financing. The firm maximizes $\gamma(p(a-p) - F) - (1-\gamma)B - c(a-p)$ subject to: $pq = p(a-p) \geq cq = c(a-p)$. F is the face value of debt.

The solution gives us $p = \frac{a+c/\gamma}{2}$.

The banker's expected payoff equals: $\gamma F = c(a-p) = c(a - \frac{a+c/\gamma}{2}) = c\frac{a-c/\gamma}{2}$. It implies $F = \frac{c(\gamma a - c)}{2\gamma^2}$.

The firm's profit equals

$$\Pi = \frac{\gamma(a-c/\gamma)^2}{4} = \frac{(\gamma a - c)^2}{4\gamma} - (1-\gamma)B \tag{41}$$

The comparison of (39) and (41) leads to the first part of Proposition 4.

If $b > 0$, condition (40) will be: $c + b \leq \frac{\gamma a}{3}$ or $\gamma \leq \frac{3(b+c)}{a}$ and the firm's profit under crowdfunding is

$$\frac{(\gamma a - c - b)^2}{4\gamma}$$

Then one can compare this with (35): this leads to the second part of the proposition. If $\gamma \leq \max\{\frac{3(b+c)}{a}, \frac{4B-2ab-\sqrt{16B^2-16abB+4a^2b^2+6Bb^2}}{8B}\}$

or $\gamma \geq \frac{4B-2ab+\sqrt{16B^2-16abB+4a^2b^2+6Bb^2}}{8B}$ a bank loan is better than crowdfunding.

Proof of Lemma 4. Consider a situation where type l selects KIA and type h selects AON. First we have

$$\Pi_h = \frac{\pi(1+\pi)(a_h - c)^2}{4} \tag{42}$$

$$\Pi_l = \frac{\pi(a_l - c)^2}{2} \tag{43}$$

where Π_j is the equilibrium profit of type j (all calculations are based on the symmetric information case for each type described in Section 6.1). Suppose that l mimics h and chooses AON. We have

$$\Pi_{lh} = \pi(\frac{(a_h - c)^2}{4} + \pi\frac{(a_h - c)^2}{4})$$

Comparing this with (43) we find that the former is greater if

$$\frac{1+\pi}{2} < (\frac{a_l - c}{a_h - c})^2 \tag{44}$$

Suppose that h mimics l and chooses KIA. We have

$$\Pi_{hl} = \pi\frac{(a_l - c)^2}{4} + \pi\frac{(a_l - c)^2}{4}$$

Comparing with (42) we find that h does not deviate if

$$\frac{1+\pi}{2} \geq (\frac{a_l - c}{a_h - c})^2 \tag{45}$$

Note that conditions (44) and (45) can not hold simultaneously because $\pi \leq 1$ and therefore this equilibirum does not exist.

The proof is similar for other cases so it is omitted for brevity.

Proof of Proposition 5. Consider a situation where type l selects KIA and type h selects AON. First we have

$$\Pi_h = \frac{\pi(1+\pi)(a_h - c)^2}{4} \tag{46}$$

$$\Pi_l = \frac{\pi(a_l - c)^2}{2} \tag{47}$$

where Π_j is the equilibrium profit of type j (all calculations are based on the symmetric information case for each type described in Section 6.1). Suppose that l mimics h and chooses AON. We have

$$\Pi_{lh} = \pi((p_{1h} - c)(a_h - p_{1h}) + \pi\frac{(a_l - c)^2}{4})$$

where $p_{1l} = \frac{a_l + c}{2}$ and $p_{1h} = \frac{a_h + c}{2}$.

We have

$$\Pi_{lh} = \frac{\pi(a_h - c)^2}{4} + \frac{\pi^2(a_l - c)^2}{4}$$

Comparing this with (47) we find that the former is greater if

$$\pi < 2 - (\frac{a_h - c}{a_l - c})^2 \tag{48}$$

and therefore type l has no incentive to deviate.

Suppose that h mimics l and chooses KIA. We have

$$\Pi_{hl} = \pi(\frac{(a_l - c)^2}{4} + \pi\frac{(a_h - c)^2}{4}) + (1 - \pi)\pi\frac{(a_l - c)^2}{4}$$

Comparing with (46) we find that h does not deviate if

$$\frac{\pi}{2 - \pi} > (\frac{a_l - c}{a_h - c})^2 \tag{49}$$

Note that conditions (48) and (49) do not contradict each other. It is because the right side of (49) is smaller than that of (48). Indeed let $x = (\frac{a_l - c}{a_h - c})^2$. Then the following makes the comparison described in the previous sentence:

$$x < 2 - \frac{1}{x}$$

, which always holds. For brevity, we omit the analysis of equilibrium and also the case where type l selects equity-based crowdfunding and type h selects AON.

Consider a situation where type h selects KIA and type l selects AON. First we have

$$\Pi_h = \frac{\pi(a_h - c)^2}{2} \tag{50}$$

$$\Pi_l = \frac{\pi(1 + \pi)(a_l - c)^2}{4} \tag{51}$$

Suppose that l mimics h and chooses KIA. We have

$$\Pi_{lh} = \pi(\frac{(a_h - c)^2}{4} + \pi\frac{(a_l - c)^2}{4}) + (1 - \pi)\frac{(a_h - c)^2}{4}$$

This is greater than (51) because $a_h > a_l$ and $\pi < 1$. So a situation where type h selects KIA and type l selects AON is not an equilibrium.

Finally, consider a situation where type h selects equity-based crowdfunding. We have

$$\Pi_h = \frac{\pi(a_h - c)^2}{2}$$

$$\Pi_l \leq \frac{\pi(a_l - c)^2}{2} \tag{52}$$

(if l selects KIA, (52) holds as an equality). Suppose that l mimics h and chooses equity-based crowdfunding. l's profit Π_{lh} then equals

$$\Pi_{lh} = (1 - \alpha_h)(\pi p_{1l}(a_l - p_{1l}) + \pi(p_{2l} - c)(a_l - p_{2l}))$$

where:

$$\alpha_h = \frac{c}{c + \pi(a_h - c)}$$

$$p_{1l} = p_{2l} = \frac{a_l + c}{2}$$

It implies

$$\Pi_{lh} = (1 - \frac{c}{c + \pi(a_h - c)})\frac{\pi a_l(a_l - c)}{2}$$

This is greater than (52) because $a_l < a_h$. Therefore l will mimic h and such an equilibrium does not exist.

Proof of Proposition 6. Consider a pooling equilibrium where both types select KIA, which is supported by off-equilibrium market beliefs that the firm is l if the market participants observe AON or equity-based crowdfunding. First of all, let us verify non-deviation for each type to equity-based crowdfunding. h payoff in equilibrium is

$$\Pi_h = \frac{\pi(a_m - c)^2}{4} + \frac{\pi(a_h - c)^2}{4} \tag{53}$$

where $a_m = xa_h + (1 - x)a_l$.[35] If h deviates to equity-based crowdfunding it gets .

$$\Pi_h = (1 - \alpha_l)(\pi\frac{M_l}{c}(a_h - \frac{M_l}{c}) + \pi\frac{(a_h - c)^2}{4}) \tag{54}$$

where:

$$\alpha_l = \frac{c}{c + \pi(a_l - c)}$$

$$M_l = \frac{c(a_l - c)}{2}$$

Note that it follows from (17) that $M_l = \frac{c(a_l - c)}{2} < M_h = \frac{c(a_h - c)}{2}$ because $a_l < a_h$ so h will not be able to produce the optimal quantity if h deviates to equity-based crowdfunding. (53) is greater than (54) if

$$(a_m - c)^2 > \frac{\pi(a_l - c)^2(2a_h - a_l + c) - c(a_h - c)^2}{(c + \pi(a_l - c))} \tag{55}$$

So it holds if x and respectively a_m are suffciently large. If h deviates to AON it gets

$$\Pi_h = \pi(\frac{(a_l - c)^2}{4} + \pi\frac{(a_h - c)^2}{4})$$

This is less than (53) because $a_l \leq a_m$ so h does not deviate.

Off-equilibrium beliefs survive the intuitive criterion of Cho and Kreps (1987). The proof is omitted for brevity.

Now let us analyze the mispricing. Consider pooling with equity-based crowdfunding. h's profit Π_h equals

$$\Pi_h = (1 - \alpha_m)(\pi\frac{M_m}{c}(a_h - \frac{M_m}{c}) + \pi\frac{(a_h - c)^2}{4}) \tag{56}$$

[35] Note that in period 1 the funders' pre-orders are based on the belief that the quality of the product is average since it is a pooling equilibrium where all firms use the same strategy. In period 2, customers will be able to see the difference between high-quality and low-quality products.

where:

$$\alpha_m = \frac{c}{c + \pi(a_m - c)}$$

$$M_m = \frac{c(a_m - c)}{2}$$

Consider pooling with AON.

$$\Pi_h = \pi(\frac{(a_m - c)^2}{4} + \pi\frac{(a_h - c)^2}{4}) \tag{57}$$

From the comparison of (53) and (57) it follows that pooling with KIA dominates pooling with AON. Now let us compare KIA and equity-based crowdfunding. (53) is greater than (56) if

$$(a_m - c)^2(2\pi a_h - c - 2\pi a_m + 2\pi c) < c(a_h - c)^2$$

If x is sufficiently large, it holds. Indeed in the extreme case when $x = 1$ and respectively $a_m = a_h$, this condition becomes $\pi < 1$. This completes the second part of the proposition.

Now compare pooling with KIA with the separating equilibrium where h plays AON

$$\pi(\frac{(a_h - c)^2}{4} + \pi\frac{(a_h - c)^2}{4})$$

This is greater than (53) if:

$$\pi > \frac{(a_m - c)^2}{(a_h - c)^2}$$

So if x is suffciently large, pooling with KIA dominates.

Proof of Lemma 5. Consider reward-based crowdfunding.

In period 2, the firm chooses p_2 to maximize $(p_2 - c)(a - p_2)$, which gives $p_2 = \frac{a+c}{2}$.

In period 1, the firm maximizes $(p_1 - c)(a - p_1) - I$ subject to: $p_1 q_1 = p_1(a - p_1) \geq I + cq_1 = I + c(a - p_1)$. This condition means that the amount of pre-orders should cover the start-up cost (fixed costs and period 1's variable costs).

Two cases are possible. If

$$\frac{(a - c)^2}{4} \geq I \tag{58}$$

then $p_1 = \frac{a+c}{2}$.

The firm's profit over the two periods equals

$$\Pi = \frac{(a - c)^2}{4} - I + \frac{(a - c)^2}{4} = \frac{(a - c)^2}{2} - I \tag{59}$$

If (58) fails, the firm will not be able to raise the funds needed to launch production. When the required amount of initial investment is quite large, reward-based crowdfunding may not be an option.

The analysis of equity-based crowdfunding is omitted for brevity (it is very similar to the analysis in Section 6).

Proof of Proposition 8. Consider a situation where l selects reward-based crowdfunding and h selects equity-based crowdfunding.

Consider firm h. Calculations are similar to those in Section 4. In period 2, the firm chooses p_2 to maximize the entrepreneur's profit $(1-\alpha)(\gamma p_2 - c_h)(a-p_2)$, which makes $p_2 = \frac{a+c_h/\gamma}{2}$.

In period 1, after the shares are sold, the firm chooses p_1 to maximize $(1-\alpha)(\gamma p_1(a-p_1) + M - c_h q_1)$ subject to

$$M \geq cq_1 \tag{60}$$

. It implies: $p_1 = \frac{a+c_h/\gamma}{2}$. The firm's expected profit in period 1 is $\gamma p_1(a-p_1) = \gamma\frac{(a+c_h/\gamma)(a-c_h/\gamma)}{4}$. The funders' expected earnings should cover their investment cost or:

$$\alpha(\gamma\frac{(a+c_h/\gamma)(a-c_h/\gamma)}{4} + \frac{\gamma(a-c_h/\gamma)^2}{4}) \geq M \tag{61}$$

Under the optimal solution the conditions (60) and (61) will be binded because the firm can always make α as small as necessary. Then we have:

$$\alpha = \frac{c_h q_1}{\gamma\frac{(a+c_h/\gamma)(a-c_h/\gamma)}{4} + \frac{\gamma(a-c_h/\gamma)^2}{4}} = \frac{c_h\frac{a-c_h/\gamma}{2}}{\frac{\gamma a(a-c_h/\gamma)}{2}} = \frac{c_h}{\gamma a}$$

The entrepreneur's expected profit over the two periods equals:

$$(1-\frac{c_h}{\gamma a})(\frac{\gamma a(a-c_h/\gamma)}{2}) = \frac{(\gamma a - c_h)^2}{2\gamma} \tag{62}$$

Consider firm l. In period 2, the firm chooses p_2 to maximize $(\gamma p_2 - c_l)(a-p_2)$ which makes $p_2 = \frac{a+c_l/\gamma}{2}$. The firm's expected profit in period 2 is $\frac{\gamma(a-c_l/\gamma)^2}{4}$

In period 1, the firm maximizes $\gamma(p_1(a-p_1) + \frac{\gamma(a-c_l/\gamma)^2}{4}) - c_l(a-p_1)$ subject to: $p_1 q_1 = p_1(a-p_1) \geq c_l q_1 = c_l(a-p_1)$. The solution gives us $p_1 = \frac{a+c_l/\gamma}{2}$.

The firm's profit over the two periods equals

$$\Pi_l = \frac{\gamma(a-c_l/\gamma)^2}{4} + \frac{\gamma^2(a-c_l/\gamma)^2}{4} = \frac{\gamma(1+\gamma)(a-c_l/\gamma)^2}{4} \tag{63}$$

Suppose that l mimics h and chooses equity-based crowdfunding instead. l's profit Π_{lh} then equals

$$\Pi_{lh} = (1-\alpha_h)(\gamma p_{1l}(a-p_{1l}) - c_l(a-p_{1l}) + \gamma p_{2l}(a-p_{2l}) - c_l(a-p_{2l}))$$

where:

$$\alpha_h = \frac{c_h}{\gamma a}$$

$$p_{1l} = p_{2l} = \frac{a+c_l/\gamma}{2}$$

It implies

$$\Pi_{lh} = (1 - \frac{c_h}{\gamma a})\frac{\gamma a(a - c_l/\gamma)}{2} = \frac{(\gamma a - c_h)(a - c_l/\gamma)}{2} \tag{64}$$

(64) is smaller than (63) if the following holds:

$$\frac{2}{\gamma(1+\gamma)} < \frac{\gamma a - c_l}{\gamma a - c_h} \tag{65}$$

The left side of this inequality is decreasing in γ and the right side is increasing in γ. So we have two cases. *If* $\frac{a-c_l}{a-c_h} < 2$, the condition (65) does not hold for $0 < \gamma \leq 1$ and a separating equilibrium does not exist. Otherwise it holds if γ is sufficiently high.

Secondly, in order to have an equilibrium, h should not have an incentive to switch to reward-based crowdfunding. In this case, this is a trade-off between bankruptcy cost and the cost of moral hazard. If h switches to reward-based crowdfunding its payoff equals:

$$\Pi_{hl} = \frac{\gamma(1+\gamma)(a - c_h/\gamma)^2}{4}$$

This is less than (62).

Consider a situation where h selects reward-based crowdfunding and l selects equity-based crowdfunding.

Consider firm l. Similarly to the above analysis we have: $p_1 = p_2 = \frac{a+c_l/\gamma}{2}$, $\alpha = \frac{c_l}{\gamma a}$ and the entrepreneur‘s expected profit over the two periods equals:

$$\frac{(\gamma a - c_l)(a - c_l/\gamma)}{2} \tag{66}$$

Consider firm h. We have $p_1 = p_2 = \frac{a+c_h/\gamma}{2}$.

The firm's profit over the two periods equals

$$\Pi_h = \frac{\gamma(1+\gamma)(a - c_h/\gamma)^2}{4} \tag{67}$$

Suppose that h mimics l and chooses equity-based crowdfunding instead. h's profit Π_{hl} then equals

$$\Pi_{hl} = (1 - \alpha_l)(\gamma p_{1h}(a - p_{1h}) - c_l(a - p_{1h}) + \gamma p_{2h}(a - p_{2h}) - c_l(a - p_{2h}))$$

It equals

$$\Pi_{hl} = \frac{(\gamma a - c_l)(a - c_h/\gamma)}{2}$$

This is greater than (67) because $c_l < c_h$ and therefore such an equilibrium does not exist.

Proof of Proposition 9. Consider reward-based crowdfunding. In period 2, the firm chooses p_2 to maximize $(p_2 - c - b)(s_r a - p_2)$ which makes $p_2 = \frac{s_r a + b + c}{2}$

(all calculations are identical to those in section 2.1. except that the cost equals $c+b$).

In period 1, the firm maximizes $(p_1 - b - c)(a - p_1)$ subject to $p_1 q_1 = (p_1 - c)(a - p_1) \geq cq_1 = c(a - p_1)$.

Two cases are possible. If

$$(a - c - b)^2 < 4I \tag{68}$$

then the firm will not be able to raise enough funds to launch the production. Otherwise we have $p_1 = \frac{a+c+b}{2}$.

The firm's profit over the two periods equals

$$\Pi_r = \frac{(a - b - c)^2}{4} + \frac{(s_r a - b - c)^2}{4} \tag{69}$$

Consider equity-based crowdfunding. In period 2, the firm chooses p_2 to maximize $(1 - \alpha)(p_2 - c - b)(s_e a - p_2)$ which makes $p_2 = \frac{s_e a+b+c}{2}$.

In period 1, the firm maximizes $(1 - \alpha)(p_1 - b - c)(a - p_1)$ which makes $p_1 = \frac{a+b+c}{2}$.

The firm's profit equals

$$\Pi_e = (1 - \alpha)(\frac{(a - b - c)^2}{4} + \frac{(s_e a - b - c)^2}{4})$$

Since

$$\alpha(\frac{(a - b - c)^2}{4} + \frac{(s_e a - b - c)^2}{4}) = cq$$

we have:

$$\Pi_e = \frac{(a - b - c)^2}{4} + \frac{(s_e a - b - c)^2}{4} \tag{70}$$

In the case of bank loan financing we have $p_1 = p_2 = \frac{a+c}{2}$.

The firm's profit is:

$$\Pi_b = \frac{(a - c)^2}{2} \tag{71}$$

Since (69) is greater than (70) we have two cases. Resulting from the comparison of (69) and (70), the firm prefers reward-based crowdfunding to equity-based crowdfunding because $s_r > s_e$. As follows from the comparison of (69) and (71), the firm selects reward-based crowdfunding if s_r is sufficiently large or b is sufficiently small. This is not surprising given that b reflects the degree of the moral hazard cost under crowdfunding and s_r reflects the efficiency of market feedback. Otherwise, the firm takes a bank loan.

Let us now analyze the role of demand (a) on a firm's decision-making. The firm is indifferent between reward-based crowdfunding and a bank loan if:

$$\frac{(a - b - c)^2}{4} + \frac{(s_r a - b - c)^2}{4} = \frac{(a - c)^2}{2}$$

This equation can be rewritten as:

$$\frac{(a-b-c)^2}{2}+\frac{(s_r a-b-c)^2}{2}=(a-c)^2 \tag{72}$$

Since this is a quadratic equation, it implies that for any given value of I, the firm selects equity-based crowdfunding if a is either very small or very large. Otherwise it takes a bank loan.

It was shown previously, the entrepreneur's profits under the different strategies are equal to the following.

$$\Pi_r=\frac{(a-b-c)^2}{4}+\frac{(s_r a-b-c)^2}{4}-I$$
$$\Pi_e=\frac{(a-b-c)^2}{4}+\frac{(s_e a-b-c)^2}{4}-I$$
$$\Pi_b=\frac{(a-c)^2}{2}-I$$

where subscript r stands for reward-based crowdfunding, e means equity-based crowdfunding and b means bank loan.

The firm is indifferent between reward-based crowdfunding and a bank loan if

$$\frac{(a-b-c)^2}{2}+\frac{(s_r a-b-c)^2}{2}=(a-c)^2 \tag{73}$$

The firm is indifferent between equity-based crowdfunding and a bank loan if

$$\frac{(a-b-c)^2}{2}+\frac{(s_e a-b-c)^2}{2}=(a-c)^2 \tag{74}$$

Also if

$$(a-c-b)^2<4I \tag{75}$$

the firm will not be able to use reward-based crowdfunding. And if $(a-c-b)^2 \geq 4I$, the firm prefers reward-based crowdfunding over equity-based crowdfunding.

References

Agrawal, A., Catalini, C., & Goldfarb, A. (2010). The Geography of Crowdfunding. NBER Working Paper No. 16820. 10.2139/ssrn.1692661

Agrawal, A., Catalini, C., & Goldfarb, A. (2013). Some Simple Economics of Crowdfunding. Innovation policy and the economy, Volume 14. Chicago, USA: University of Chicago Press. 10.3386/w19133

Akerloff, G. (1970). The Market for Lemons: Quality Incertainty and the Market Mechanism. *Quarterly Review of Economics*, 74, 488-500. 10.2307/1879431

Ahlers, G., Cumming, D., Guenther, C., & Schweizer, D. (2015). Signaling in Equity Crowdfunding. *Entrepreneurship Theory and Practice*, 39(4), 955-980. 10.1111/etap.12157

Belleflamme, P., Lambert, T., & Schwienbacher, A. (2010). Crowdfunding: An Industrial Organization Perspective. Prepared for the Workshop Digital

Business Models: Understanding Strategies, Held in Paris on June 2010. Retrieved from http://economix.fr/pdf/workshops/2010_dbm/Belleflamme_al.pdf.

Belleflamme, P., Lambert, T., & Schwienbacher, A. (2014). Crowdfunding: Tapping the Right Crowd. *Journal of Business Venturing: entrepreneurship, entrepreneurial finance, innovation and regional development*, 29(5), 585-609. https://doi.org/10.1016/j.jbusvent.2013.07.003

Block, J., Hornuf, L., & Moritz, A. (2016). Which Updates during a Crowdinvesting Campaign Increase Crowd Participation?,

SSRN Working paper, http://ssrn.com/abstract=2781715 (accessed 19 June 2016). http://dx.doi.org/10.2139/ssrn.2781715

Booty, L. October 4, 2017. Equity or reward-based crowdfunding? Hear from both sides to make your mind up. https://realbusiness.co.uk/scale-up-hub/2017/10/04/equity-reward-based-crowfunding-hear-sides-make-mind/

Canada Media Fund. How likely is your crowdfunding campaign to succeed? Stats & Figures Update #2 (Article)

http://crowdfunding.cmf-fmc.ca/facts_and_stats/how-likely-is-your-crowdfunding-campaign-to-succeed

Chakraborty, S., & Swinney, R. (2017) Signalling to the Crowd: Private Quality Information and Rewards-Based Crowdfunding. SSRN Working Paper. http://dx.doi.org/10.2139/ssrn.2885457.

Chang, Jen-Wen, The Economics of Crowdfunding (August 30, 2016). Available at SSRN: https://ssrn.com/abstract=2827354

Chemla, Gillles and Tinn, Katrin, Learning Through Crowdfunding (December 05, 2017). Available at SSRN:

https://ssrn.com/abstract=2796435 10.2139/ssrn.2796435

Choe, H., Masulis, R., Nanda, V. (1993). Common Stock Offerings Across the Business Cycle. *Journal of Empirical Finance.* 1. 3-31. 10.1016/0927-5398(93)90003-A

Cholakova, M., & Bart C. (2015). Does the Possibility to Make Equity Investments in Crowdfunding Projects Crowd Out Reward-Based Investments? *Entrepreneurship Theory and Practice*, 39(1), 145–172. 10.1111/etap.12139

Cordova, A., Dolci, J., & Gianfrate, G. (2015). The Determinants of Crowdfunding Success: Evidence from Technology Projects. *Procedia - Social and Behavioral Sciences*, 181(11), 115-124. 10.1016/j.sbspro.2015.04.872

Cumming, D., Leboeuf, G., & Schwienbacher, A. (2014). Crowdfunding Models: Keep-it-All vs. All-or-Nothing. SSRN working paper. Retrieved June 21, 2014. 10.2139/ssrn.2447567

da Cruz, J. V. (2016). Beyond financing: crowdfunding as an informational mechanism. Université Paris 13 (CEPN, Labex ICCA) and Télécom ParisTech April. 10.2139/ssrn.2870545

Desjardins, J. July 14, 2016. 19 Weird Crowdfunding Campaigns That Failed Spectacularly. http://www.visualcapitalist.com/19-weird-crowdfunding-campaigns-failed/

Demichelis, S., & Tarola, O. (2006). Capacity expansion and dynamic monopoly pricing. *Research in Economics*, 60(4), 169-178.

10.1016/j.rie.2006.09.003

Diamond, D. (1984). Financial Intermediation and Delegated Monitoring. *The Review of Economic Studies* 51(3), 393-414. 10.2307/2297430

Fudenberg, D., & Tirole J. (1991). Game Theory. MIT Press

Gabison, G. (2015). Understanding Crowdfunding and its Regulations. How can Crowdfunding help ICT Innovation? JRC Science and Policy Report. 10.2791/562757

Graham, J. R., & Harvey, C. R. (2001). The Theory and Practice of Corporate Finance: Evidence from the Field, *Journal of Financial Economics* 60, 187-243. 10.1016/S0304-405X(01)00044-7

Harris, M. and A. Raviv A., (1991). The Theory of Capital Structure. *The Journal of Finance* 46 (1), 297-355. 10.1111/j.1540-6261.1991.tb03753.x

Hatfield, I. (2017). Increasing and diversifying finance for high-growth SMEs in the UK's regions. Report.

Hildebrand, T., Puri, M., & Rocholl, J. (2014). Adverse Incentives in Crowdfunding. Available at SSRN: http://ssrn.com/abstract=1615483.

10.2139/ssrn.1615483

Hu, M., Li, X., & Shi, M. (2014). Product and Pricing Decisions in Crowdfunding. Rotman School of Management Working Paper No. 2405552. Available at SSRN:

http://ssrn.com/abstract=2405552 or http://dx.doi.org/10.2139/ssrn.2405552. 10.2139/ssrn.2405552

Ibrahim, D. (2016). Equity Crowdfunding: a market for lemons? Working paper. http://dx.doi.org/10.2139/ssrn.2539786

Innes, R. (1990). Limited liability and incentive contracting with ex-ante action choices. *Journal of Economic Theory*, 52(1), 45–67. 10.1016/0022-0531(90)90066-S

Jensen, M., & Meckling, W. (1976). Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure. *Journal of Financial Economics* 3, 305-360. 10.1016/0304-405X(76)90026-X

Kuppuswamy, V., & Bayus, B. (2015a). A Review of Crowdfunding Research and Findings. *Handbook of New Product Development Research*, Forthcoming. Available at SSRN:

https://ssrn.com/abstract=2685739 or http://dx.doi.org/10.2139/ssrn.2685739.

http://dx.doi.org/10.2139/ssrn.2685739

Kuppuswamy, V., & Bayus, B. (2015b). Crowdfunding Creative Ideas: The Dynamics of Project Backers in Kickstarter. UNC Kenan-Flagler Research Paper No. 2013-15. Available at SSRN: http://ssrn.com/abstract=2234765 or http://dx.doi.org/10.2139/ssrn.2234765. 10.2139/ssrn.2234765

Loane, S., Ramsey, E., & Ibbotson, P. (2016). Putting your money where your mouse is, the case of rewards-based (pre selling) crowdfunding:

Antecedents, consequences and cognitive effects of failure. Working paper. 10.1177/0266242614539363

Leland, H., & and Pyle, D. (1977). Informational Asymmetries, Financial Structure, and Financial Intermediation. *Journal of Finance* 32(2), 371-87. 10.1111/j.1540-6261.1977.tb03277.x

Miglo, A., (2011). Trade-Off, Pecking Order, Signaling, and Market Timing Models, in H. K. Baker, G. S. Martin Capital Structure and Corporate

Financing Decisions: Theory, Evidence, and Practice, Wiley and Sons, Ch. 10, 171-191. 10.1002/9781118266250.ch10

Miglo, A. (2017). Financing of Entrepreneurial Firms in Canada: An Overview. working paper. 10.2139/ssrn.2793613

Miglo, A. (2016). *Capital Structure in the Modern World*. Palgrave/McMillan/Springer.

10.1007/978-3-319-30713-8

Modigliani, F., & Miller, M. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment. *American Economic Review* 48 (3), 261–297.

Mollick, M. (2014). The dynamics of crowdfunding: An exploratory study. *Journal of Business Venturing* 29, 1–16.

https://doi.org/10.1016/j.jbusvent.2013.06.005

Mollick, E. R. (2015). Delivery Rates on Kickstarter. Available at SSRN: https://ssrn.com/abstract=2699251. 10.2139/ssrn.2699251

Moores, C. (2015). Kickstart My Lawsuit: Fraud and Justice in Rewards-Based Crowdfunding. UC Davis.

Moritz, A., & Block, J. (2014). Crowdfunding: A Literature Review and Research Directions. Available at SSRN: http://ssrn.com/abstract=2554444 or http://dx.doi.org/10.2139/ssrn.2554444. 10.2139/ssrn.2554444

Myers, S., & Majiluf, N. (1984). Corporate Financing Decisions When Firms Have Information Investors Do Not Have. *Journal of Financial Economics.* 13. 187-221. 10.1016/0304-405X(84)90023-0.

Noe, T., C Nachman, D. (1994). Optimal Design of Securites under Asymmectric Information. *Review of Financial Studies.* 7. 1-44. 10.1093/rfs/7.1.1.

Paakkarinen, P. (2016). Success Factors in Reward based and Equity based Crowdfunding in Finland. Master's thesis

Salman, SH. (2016). The Global Crowdfunding Industry Raised $34.4 Billion In 2015, And Could Surpass VC In 2016. Dazeinfo.com. Posted on January 12, 2016http://dazeinfo.com/2016/01/12/crowdfunding-industry-34-4-billion-surpass-vc-2016/

Strausz, R. (2017). Crowdfunding, demand uncertainty, and moral hazard - a mechanism design approach. *American Economic Review*, 107(6): 1430-76. 10.1257/aer.20151700.

Titman, S., & Wessels, R. (1988). The Determinants of Capital Structure Choice. *Journal of Finance.* 43. 1-19. 10.1111/j.1540-6261.1988.tb02585.x.

Winborg, J., & Landstrom, H. (2001). Financial bootstrapping in small businesses: Examining small business managers' resource acquisition behaviors. *Journal of Business Venturing* 16, 235-254. https://doi.org/10.1016/S0883-9026(99)00055-5

Xu, A., Yang, X., Rao, H., Fu, W., Huang, S., Bailey, B. (2014). Show Me the Money! An Analysis of Project Updates during Crowdfunding Campaigns. Proceedings of SIGCHI Conference on Human Factors in Computing Systems Pages 591-600. 10.1145/2556288.2557045.

Xu, T. (2017). Learning from the Crowd: The Feedback Value of Crowdfunding. University of British Columbia working paper.
http://dx.doi.org/10.2139/ssrn.2637699
Xue, X. (2017). Financial Intermediary Competition, Information Acquisition and Moral Hazard: Evidence from Peer-to-peer Lending Platforms. Working paper.
http://www.law.northwestern.edu/research-faculty/searlecenter/events/internet/documents/Xue_competi
Zhang, N., Datta, S., Kannan, K. N. (2015). An Analysis of Incentive Structures in Collaborative Economy: An Application to Crowdfunding Platform. SSRN Working Paper. http://dx.doi.org/10.2139/ssrn.2518662