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Broere, Mark and Christmann, Robin

Leibniz FH, Leibniz FH

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Signaling and Fraud when Crowdfunding Campaigns Compete for Pledges

MARK BROERE ROBIN CHRISTMANN

Zusammenfassung / Abstract:

Crowdfunding as a part of micro-finance has received considerable attention from the public and among researchers, both due to its novel form of collecting funds and the emergence of fraud and misconduct to the disadvantage of lay backers. We develop an adverse selection model of reward-based crowdfunding that introduces Bertrand-style competition between campaign owners. We find that the traditional result in the literature about successful separation of high-type and low-type creators does no longer hold when accessible information about quality becomes less reliable and the market for the high-quality product grows. Under certain conditions, we also observe an instability in competition where campaign owners randomize between withdrawing to a certain market niche and price competition. All this gives rise to fraud in equilibrium. In this perspective, crowdfunding scams resemble a bet on market demand and are often able to evade liability. We then discuss specific remedies and provide insights for platform policy and regulation.

Fachrichtung / Field of Study: Economics

Klassifikation / Classification: G14, G18, K42 (JEL)

Schlagworte / Keywords: adverse selection; price competition; reward-based crowdfunding; fixed funding; enforcement

1. INTRODUCTION

Crowdfunding (=CF) campaigns have become an alternative, rapidly growing way to fund projects and make innovations ready for the market. As a potential substitute for traditional venture capital and bank financing, entrepreneurs who seek to collect funds from the crowd usually start their campaigns on digital platforms, such as *kickstarter* or *Indiegogo*. Despite the common success stories, any investment decision comes at a risk. In contrast to traditional venture capital investors and banks, however, backers of crowdfunding campaigns are typically private investors and consumers, who may be less able to cope with some of the underlying economic problems of crowdfunding: asymmetric information in this market may prevent backers from successfully distinguishing between high-value and low-value projects, entrepreneurs may choose to misrepresent their project to make higher profits, and the collected funds may be misappropriated after the campaign.

While lawmakers scramble to enact laws to cover this alternative form of finance, the specific form of reward-based crowd funding seems to receive much less regulatory attention. In such campaigns, backers of successful campaigns receive a final product as the reward for their pledge, making them both investors and consumers at the same time. From an efficiency perspective, reward-based crowdfunding offers an alternative, appealing way for entrepreneurs to reveal the size of a market of a new product before starting production and thus before large expenses are sunk. Nevertheless, product descriptions in campaigns about prototypes may be exaggerated, inaccurate or even false. Eventually, backers may learn that production never started and the funds are gone, that the product is of poor quality or inadequate for the intended use.

Economic scholars have studied the occurrence of adverse selection in crowdfunding campaigns and emphasized the importance of signaling to allow backers to infer the true quality of announced products. A remarkable proposition was substantiated by Chakraborty and Swinney (2021) who find that such signaling can always be successful, i.e. a so-called separating equilibrium where good-types and bad-types are clearly distinguishable is obtainable, and thus fraud can be ruled out by rational economic agents. We will demonstrate that this result may collapse once we consider heterogeneous backers and campaign owners who compete for pledges. In other words, the problem of fraud in crowdfunding is not ruled out so easily.

In this paper, we seek to determine (1) under which conditions the result of a separating equilibrium between high and low-quality creators cannot be obtained when creators compete for pledges, and (2) how legal rules, platform design or campaign strategies can mitigate this persisting adverse selection problem. Our game theoretic approach particularly builds on the existing works of Bagwell and Riordan (1991), and Chakraborty and Swinney (2021). In contrast to previous research, our model does not rely on the assumption that some "expert" agents exist who always recognize the creator´s true type and thus constitute a considerable threat to low-type entrepreneurs trying to deceive the market. Furthermore, we treat campaigns with distinguishable products as targeting different groups of consumers in the market. In other words, low-quality creators who faithfully reveal their type do not have the same prospects with regard to market size as high-quality creators. Lastly, we include feedback by other backers, commenting on projects via the host platform, into the game as an imperfect signal of the creator´s true type. Feedback, however, may be inadequate if provided by *friends, family, and fools* – and may be manipulated by creators.

This research outline is structured as follows: Chapter 2 presents a brief summary of the relevant literature, and chapter 3 describes the regulatory framework. In chapter 4 we will then outline our adverse selection model and determine equilibria in chapter 5. Chapter 6 then concludes by discussing several remedies against the persistence of fraud in equilibrium.

2. LITERATURE

The crowdfunding literature originates from the fields of finance, industrial economics, and principal-agent theory (see Wessel et al. 2015, Moritz and Block 2016, or Kuppuswamy and Bayus 2018 for an overview). To date, crowdfunding has received considerable attention in the literature. One focus is the design of platforms and fees (e.g., Belavina et al. 2020, Mollick 2015, Strausz 2017, and Wessel 2016). Another focus is on the design of optimal campaigns and signaling quality to backers (e.g., Ahlers et al. 2015, Chakraborty and Swinney 2021, Chemla and Tinn 2018, Cumming et al. 2019, Jiménez-Jiménez et al. 2021, Sayedi and Wessel 2019).

We focus on the latter area, and in particular on the reward-based crowdfunding model. Similar to Miglo (2023), we observe a discrepancy between theoretical and empirical research regarding the recognition of quality in reward-based crowdfunding campaigns. While theoretical models suggest that creators can successfully signal their quality to backers (e.g., Cumming et al. 2019; Chakraborty and Swinney 2021), empirical research shows that successful campaigns do not always deliver on their promises and that some creators engage in fraudulent behavior (e.g., Appio et al. 2020, Blaseg et al. 2020, Cumming et al. 2023, Hainz 2018, Mollick 2014).

Cumming et al. (2019) find that creators can signal their quality by choosing the fixed funding model ("all-or-nothing") rather than the flexible funding model offered by some platforms. They support this with empirical evidence showing that fixed funding campaigns have larger funding goals and are more likely to be successful. Other authors examine reward price and campaign goal. Sayedi and Baghaie (2015) suggest that setting a low funding target and a high pre-order price can credibly signal high creator quality. In contrast, Chakraborty and Swinney (2021) find that setting a high campaign target or a low reward price is conducive to signaling high quality. Bolandifar et al. (2023) include the benefits to the creator of continued sales after a successful campaign (see also Cumming et al. 2019 and Gao et al. 2022) and find that entrepreneurs can signal quality to backers through a low campaign price or a commitment to a future sales price.

None of the above papers consider competition among entrepreneurs. Miglo (2020) studies a model in which two firms can compete by using crowdfunding before starting regular sales and finds that firms can signal high demand by using crowdfunding. In contrast to their work, we consider two entrepreneurs competing in a Bertrand-style price competition on a crowdfunding platform. Li and Cao (2023) also study competition between entrepreneurs, but do not consider a simultaneous choice of campaign design as in our setting.

All of these papers identify separating equilibria, suggesting that entrepreneurs can credibly signal their quality to backers (e.g., Chakraborty and Swinney 2021: "the high quality creator can virtually always distinguish herself from the low quality creator", p. 26). To our knowledge, Miglo (2023) is the only paper to find that there is no efficient signaling equilibrium. Our model extends this research by considering competition among entrepreneurs.

A related strand of research examines the role of social information for online platforms. Wessel et al. (2015) empirically study the effect of manipulated social media ratings (Facebook likes) on the number of backers supporting a campaign. They find that initial increases in backer participation following a fake social media campaign are mitigated by subsequent periods of reduced participation (see also Kuppuswamy and Bayus 2013 on the role of social information). Wang et al. (2018) empirically study the impact of comments and replies on crowdfunding platforms on campaign success in a Chinese setting (see also Papanastasiou 2023, on dispute resolution from malicious reviews). Outside of crowdfunding, scholars have also examined the manipulation of online feedback (e.g., Dellarocas 2006 and Mayzlin 2012). Surprisingly, some researchers demonstrated that, given market power prevails in a market, social outcome actually improves when feedback manipulation is present (see, e.g., Wangenheim 2019).

3. REGULATION

Asymmetric information in crowdfunding markets and limited regulatory control provide opportunities for creators to misappropriate funds collected from backers.[1] In the past, several fraudulent campaigns have received considerable media attention (e.g., the 'Dragonfly Futurefön' campaign on the Indiegogo platform). Fraud can deter investors and has the potential to damage the nascent crowdfunding market severely (Cumming et al. 2023, Hainz 2018).

Given increasing market volumes, regulators across the globe scramble to enact laws on crowdfunding (e.g., 2020/1503/EU, SF-BG, JOBS Act, SEC's Regulation Crowdfunding). The broad focus of these new rules is on equity- and lending-based crowdfunding campaigns that involve an offering of equity or debt securities. Donation- and reward-based crowdfunding projects, however, generally fall outside the scope of the financial supervisory authorities (Bradford 2018, Cicchiello 2019, and Wenzlaff et al. 2020)[2]. Regulation of these markets is therefore largely limited to consumer protection laws that would apply to any commercial sale of goods (Bradford 2018 and Wenzlaff et al. 2020).

In the United States, consumers are protected from false and misleading disclosures or non-delivery of the product by the Federal Trade Commission Act on Unfair or

[1] Only a small number of fraud cases have been detected: Cumming et al. (2016) identify less than 1 percent of all campaigns in a sample of reward-based funding campaigns spanning a five-year period in a set of nine countries as fraudulent. The number of undetected cases may be higher. Hainz (2018) suggests that up to 3 percent of all reward-based crowdfunding campaigns could involve fraud

[2] Exceptions to this rule are the required permits for the collection of donations in Denmark and Finland (Wenzlaff et al. 2020).

Deceptive Acts or Practices and by corresponding fraud statutes on state level[3] (Cascino et al. 2018). However, public enforcement of these provisions has been extremely rare, which Cumming et al. (2018) attribute to the large cost and difficulty of proving that a deception was intentional. In some states, backers may seek legal recourse through private litigation, which may also include class actions (Cascino et al. 2018). The typically small value of backers' claims is viewed as a significant obstacle to private litigation (Cumming et al. 2018). In Europe, the level of consumer protection varies across national members. At a European level, the e-Commerce Directive (2000/31/EC) and the Consumer Rights Directive (2011/83/EU) apply. The Directive on Consumer Rights grants online purchasers of goods and services a far-reaching right of withdrawal without justification within 14 days of receipt of the goods. Klöhn (2018) sees this as one reason for lower volumes of reward- and donation-based crowdfunding in Europe.

4. MODEL SETUP

In this chapter, we present an adverse selection model featuring Betrand-style price competition between campaigns in reward-based crowdfunding. Our approach particularly builds on the setup of Chakraborty and Swinney (2019) to the extent that we stylize uncertainty about the number of backers interested in a campaign (i.e. the "size of the market") as a uniformly distributed random variable. In our model, however, we allow for heterogenous preferences of backers and the prospect of seizing the bigger market that motivates a potential fraud of a creator. Furthermore, we leave the monopolistic framework

[3] These may vary considerably in their stringency (Cascino et al. 2018).

of Chakraborty and Swinney (2021) and consider the impact of competition between creators.

Two creators, one of a high-quality product and one of a low-quality product, launch crowdfunding campaigns and compete for pledges. Image that the high-quality product is widely useful and offers many appealing features for consumers while the low-quality product is rather basic. Two different groups of backers may support such a campaign, but one group is only interested in the high-quality product, the other group is only concerned with prices and the basic features. Such a setting allows us to capture the relevant scenario where a creator makes an exaggerated (i.e. false) claim about the product to attract more backers, although this is more of an illusion than reality. Under asymmetric information, backers cannot observe creators´ true types and rely on an imperfect quality signal provided by the crowdfunding platform to make this distinction.

Consider the producer side: the product, which serves as the reward in the crowdfunding campaign, can be either of high quality or low quality. We will refer to the correspondent creator as either being “H-type”, given she is the creator of the high-quality product, or “L-type” otherwise. Starting the production process, a creator incurs fixed costs S and zero variable costs. Note that production costs are the same for both types in our setup. This can be interpreted as two creators who differ in their level of proficiency and competence, thus only the able creator (“H-type”) manages to produce the high-quality product for a given cost. Following Chakraborty and Swinney (2021, p. 10), we regard the focus on fixed costs as adequate to capture the fact that only campaigns which collect sufficient funds can move to the production phase. We make the simplifying (“duopoly”) assumption that only one "H-type" and one "L-type" creator exist, and that this is common knowledge. While creators know their true type, backers do not and will attempt to infer the creator´s type from campaign design and quality signals available on the platform. Given this setting, creators simultaneously choose their optimal campaign design (*p, C*) by specifying the price of the reward *p* and the campaign funding target *C*.

Imagine the demand side as follows: two groups of backers, A and B, exist on the platform. Group A are backers who seek just the H-type product and who do not regard the other product as an adequate substitute of any kind. Thus, they show a valuation v_H for the H-type product, and their willingness-to-pay for the L-type product is zero. Group B consists of price conscious backers who do not care about higher quality. Thus, B-backers express a willingness-to-pay for both products of v_L. Assume that the valuation of Group A for H-quality exceeds the willingness-to-pay of Group B, thus $v_H > v_L > 0$ applies. Market size is a random variable N, which stylizes the total number of backers that may pledge to a campaign. Consider that N is uniformly distributed in the interval [0; N_A] for the "A-backers" and in the interval [0; N_B] for the "B-backers". Thus, the expected market size for a campaign is contingent on product quality. Every backer can only make one pledge. We assume that the maximum number of backers ($N_A; N_B$) is sufficient to fund the production of both products and that the market for the high-quality product is more profitable, implying $v_H N_A > v_L(N_A + N_B) > v_L N_B \geq$. In other words, the H-type creator will aim for the higher willingness-to-pay from the quality-oriented "A-backers", and the L-type creator is tempted to mimic this behavior. Both creators face a positive, but uncertain prospect of campaign success.

Imagine a crowdfunding platform hosts both campaigns. The Platform applies the "All-Or-Nothing"-principle (also labelled "fixed funding"), thus only campaigns that achieve their announced funding goal receive the collected funds. Pledges to failed campaigns, however, are returned to backers. For each campaign, the platform provides a public signal t to backers that is correlated with the creator´s true type. This signal can be interpreted as observable feedback on the campaign which, for example, is given by other backers who comment on the product quality and prospects. The signal could also be part of a recommender system by the platform which tries to provide quality information to its customers. Let the signal be dichotomous in nature, $t \in \{h; l\}$, with the conditional probabilities $\Pr(h|H) = 1 - \alpha$ and $\Pr(h|L) = \alpha$. Note that we simplify by assuming that type I and type II errors are equally probable. The signal is meaningful if $\alpha \neq 0.5$. Without loss of generality, we focus on cases where the observation of h indicates a higher probability that the creator is truly of the H-type, i.e. $\alpha < 0.5$ applies.

As two campaigns are launched, backers observe the realization of the two signals, (t_H, t_L), where t_H is the realized signal related to the truly H-type campaign and t_L to the truly L-type campaign. Given that only group A backers value the two products differently, A-backers will form posterior beliefs $\mu_A(H|s,t)$ that a campaign is of the H-type when they observe the respective campaign designs $s = \{(p_H, C_H), (p_L, C_L)\}$ and signal realizations $t = (t_H, t_L)$. An A-backer makes a pledge if only for any reward price p the condition $p \leq \mu_A(H|s,t)v_H + (1 - \mu_A(H|s,t)) \cdot 0$ applies. A-backers will update their belief according to Bayes´ rule if the realization of the signal is informative, i.e. (h,l) or (l,h) is observed. In this case, they pledge to the campaign where h is observed if the reward price does not exceed the expected willingness-to-pay, i.e. $p \leq \frac{(1-\alpha)^2}{(1-\alpha)^2+\alpha^2} v_H = \overline{P}$ applies. If campaign designs are identical and the realization of the signal is not informative to backers, i.e. (h, h) or (l, l) is observed, then A-backers stand a fifty-fifty chance to pledge to the desired H-type campaign. Consequently, they pledge to a random campaign if the price p is lower or equal to the expected valuation, that is, if the condition $p \leq {}^{v_H}/_2 = \underline{P}$ holds.

The timing of the game is displayed in *Figure 1*: creators choose their campaign design and thereby specify reward price and funding target. Backers observe the campaigns and the platform signals and update their beliefs on the creator´s true type. If the expected valuation of the reward is higher or equal to the reward price, backers will make a pledge. If the total amount of pledges meets the funding goal, the creator receives the collected funds, starts production, and delivers the reward to backers. If the funding goal is not met, all pledges are refunded, and the game ends.

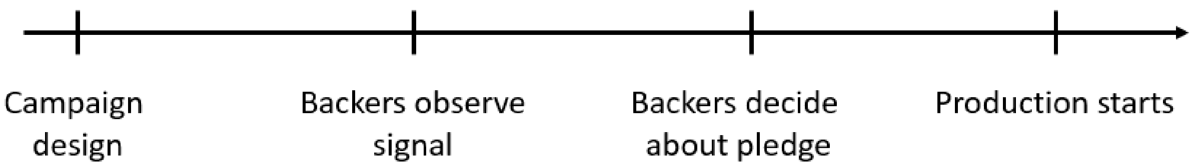

Fig. 1. Timing of the Game.

4. CAMPAIGN DESIGN AND SIGNALING FAILURES

5.1 Methodology

In this chapter, we will first present the equilibrium concept and consider the ideal case of campaigns under complete information. We will then go one step further and introduce asymmetric information to the game. This will allow us to establish under which conditions the outcome of a separating equilibrium, i.e. an equilibrium where backers can safely infer the quality of the campaigning products, will fail and thus fraud occurs with positive probability. Given that each creator has two strategy parameters to design the profit-maximizing campaign, the reward price and the campaign goal, we will analyze the strategic use for each parameter separately and then discuss our findings.

We apply the concept of perfect Bayesian equilibrium to identify credible outcomes where chosen strategies are mutual best responses, beliefs are consisted with the strategies played, and strategies are consistent with the beliefs. More specifically, a perfect Bayesian equilibrium (PBE) in this game of asymmetric information consists of the strategy profile $s^* = \{(P_H, C_H), (P_L, C_L)\}$, and A-type backers´ beliefs $\mu_A = prob(H|\{s_i, s_{-i}\} \cap (t_i, t_{-i}))$ about the probability that creator i is of the H-type, given observed campaigns s and two feedback signals t, "such that, at any stage of the game, strategies are optimal given the beliefs, and the beliefs are obtained from the equilibrium strategies and observed action using Bayes´ rule" (FUDENBERG/TIROLE 1999, p. 326).

5.2 Complete Information

In the ideal world of complete information, backers observe the true type of the product. Following our model setup, the expected profit for a creator of type $i \in \{H, L\}$ targeting only backers of group $j \in \{A, B\}$ gives

$$\Pi_i(v_i, C_i) = \int_{\frac{C_i}{p_i}}^{N_j} (p_i N - S) \frac{1}{N_j} dN \qquad (1)$$

For a given realized number of backers N ("market size"), the successful creator collects revenue $p_i N$ and bears production costs S. The CF campaign, however, is only successful if the collected funds at least equal the campaign goal C_i, which requires the minimum quantity of $\frac{C_i}{P_i}$ backers. Every realization of the market size occurs with equal probability $\frac{1}{N_j}$. Note that the profit can never be negative for $C_i \geq S$, as only successful campaigns lead to the production of the product.

As specified in the previous chapter, the market for the high-quality product is more profitable for both creators. The profit-maximizing campaign *(p, C)* for the H-type creator, targeting backers of group A then yields the expected profit

$$\Pi_H(v_H, S) = \int_{\frac{S}{v_H}}^{N_A} (v_H N - S) \frac{1}{N_A} dN = \frac{N_A}{2} v_H + \frac{S^2}{2 N_A v_H} - S \quad (1)$$

Similarly, the optimal campaign for the L-type creator would be $\Pi_L(v_L; S)$ for a maximum market size N_B. Note that the L-type cannot sell to A-group backers as they do not appreciate his product. Given these considerations, it is straightforward that choosing $P_i = v_i$ is the highest possible price that a creator of type *i* can achieve in the market. Any higher price would only lose backers´ support, any lower price would require a higher funding goal, and this increases failure risk. Lowering the funding goal is not acceptable to the creator as this allows outcomes with negative profits, given the production costs, without any gains in revenue. Raising the funding goal increases only the risk of campaign failure and thereby reduces expected profits for the creator.

Leaving the 'perfect world' of complete information, creators can use the reward price or the campaign goal to signal their type.

5.3 Reward Price as Quality Signal

Under asymmetric information, backers do not know the true types of the creators, but they observe the realization of the feedback signal, (t_H, t_L). The L-type then may have an incentive to mimic the H-type´s campaign in order to increase his profits. If this is feasible, then both campaigns are identical, and a pooling equilibrium (PE) exists. If the two campaigns show distinct reward prices *and* backers can infer the true type with certainty, a separating equilibrium (SE) exists. In the following, we present the outcome of the game contingent on the accuracy of the feedback signal.

Two borderline cases are straightforward. If the probability of an erroneous feedback signal is zero ($\alpha = 0$), the observed signal reveals the creator´s type with certainty. Thus, the outcome is clearly identical to the complete information setup. If the signal is completely uninformative ($\alpha = 0.5$), backers cannot distinguish the creator´s type. Therefore, both creators are caught in a Bertrand price competition. As there are no marginal costs and campaigns can never generate losses, this leads to a significant decline in prices. Eventually, reward prices are so close to zero that all campaigns fail in equilibrium. We refer to this outcome as '*platform failure*'.

Proposition 1. *(i) For $\alpha = 0$, there exists a SE with $s^* = \{(v_H, S), (v_L, S)\}$. (ii) For $\alpha = 0.5$, there exists a PBE with $s^* = \left\{\left(p_H \leq \frac{S}{N_A+N_B}, S\right), \left(p_L \leq \frac{S}{N_A+N_B}, S\right)\right\}$, A-type backers´ beliefs are $\mu_A(H|s,t) = 0.5$, and all campaigns fail.*

Proof. See Appendix A1.

Leaving these borderline cases, we now consider a feedback signal that is informative to some extent, i.e. the realizations of the signal are imperfectly correlated with the creator´s true type ($0 < \alpha < 0.5$). Under information asymmetry, the high-quality creator needs to signal her type to A-backers to attract pledges from this group. Given identical production costs of H-type and L-type creators, her signaling power comes only from the feedback signal: with probability $(1-\alpha)^2$, campaign feedback correctly identifies her as the H-type while she is wrongly identified as the L-type with the considerably lower probability α^2. This means that the L-type´s expected profit is lower than the H-type´s expected profit even when the campaigns are indistinguishable, and backers fully rely on the signal. Given this background, we will establish the following three possible scenarios: (i) separation, (ii) pooling, and (iii) instability in competition. Only scenario (i) can prevent fraud in equilibrium.

(i) separation

As the feedback signal is imperfect, separation always comes at a cost for the H-type. We will show that for a signal accuracy of $0 < \alpha \leq \alpha_1$, the H-type will still be able to charge the complete information price v_H and rely on favorable signal realizations. In the range of $\alpha_1 < \alpha \leq \alpha_2$, the H-type will additionally have to lower the reward price to prevent a pooling equilibrium.

We derive the conditions for the separating equilibrium: the H-type will only signal her type and incur signaling costs when a separating equilibrium is more profitable than a pooling one. The analysis is complicated by the fact that the H-type can decide to allow pooling at the higher reward price $\overline{P}$, or at the lower price $\underline{P}$.[4] Plainly, the former option has the higher price, the latter option the higher quantity. We thus make the following case distinction: a pooling H-type will prefer pooling at the higher price $\overline{P}$ to pooling at $\underline{P}$ only if $\int_{\frac{S}{(1-\alpha)^2\overline{P}}}^{N_A} \left((1-\alpha)^2\overline{P}N - S\right)\frac{1}{N_A}dN \geq \int_{\frac{S}{[(1-\alpha)^2+\alpha(1-\alpha)]\overline{P}}}^{N_A} \left([(1-\alpha)^2 + \alpha(1-\alpha)]\underline{P}N - S\right)\frac{1}{N_A}dN$ holds. Let this condition by binding for $\alpha = \hat{\alpha}$. Then, the high-quality creator will consider pooling at the high price only if $\alpha \leq \hat{\alpha}$, i.e. the probability of false feedback is below a certain threshold.

Furthermore, if she were to separate, the campaign of the high-quality creator has to be designed in a way that mimicking is not profitable for the L-type. Let $\Pi_L^{sep}(v_L, S)$ be the L-type´s profit when focusing on the B-backers and $\Pi_L^{pool}(P, S)$ his profit when mimicking a campaign (P, S)

[4] Pooling at the higher price implies that A-backers will only pledge on a favorable signal realization, which occurs with probability α^2. Pooling at the lower price implies that backers will also pledge if the signal is uninformative, which occurs with probability $2\alpha(1-\alpha)$. In the latter scenario, however, backers cannot distinguish between the two campaigns and each campaign receives pledges from half of these backers (as in the traditional Bertrand price fashion).

of the H-type creator and backers pledge only on a favorable signal realization. Then, the L-type creator will not pool if $\Pi_L^{pool}(P,S) \leq \Pi_L^{sep}(v_L,S)$ applies, which yields the following inequality:

$$\int_{\frac{S}{\alpha^2 P}}^{N_A} (\alpha^2 PN - S)\frac{1}{N_A}dN \leq \frac{N_B}{2}v_L + \frac{S^2}{2N_B v_L} - S \tag{2}$$

If the H-type creator chooses a reward price P that fulfills this inequality, then this prevents a pooling strategy of the L-type. Using (2), we find the required reward price P must hold to

$$P \leq \frac{\sqrt{\left(\frac{N_B}{2}v_L + \frac{S^2}{2N_B v_L}\right)^2 - S^2} + \frac{N_B}{2}v_L + \frac{S^2}{2N_B v_L}}{\alpha^2 N_A} = P_1 \tag{3}$$

For $v_H \leq P_1$, the high-quality creator can choose the identical reward price of the complete-information campaign, and still the L-Type will not be able to imitate this campaign. Note that even though the reward price is at the same level, the H-type creator still incurs a signaling cost. As backers have to make their pledge contingent on the observation of the informative signal, i.e. (h,l) or (l,h), she can only collect lower fundings of $(1-\alpha)^2 v_H N$ for a given market size N. Inserting $v_H = P$ in (3) and solving for the probability α, we can identify a threshold $\alpha \leq \alpha_1$ until which the H-type will not have to lower the reward price in order to credibly signal her type.

For $v_H > P_1$, the H-type must now lower the reward price according to (3) and thus incur additional costs signaling costs in order to maintain a separating equilibrium. It is easy to see from (3) that she must lower the price more if the probability of an erroneous signal is higher or the larger the A-backer market is in size. As the reward price falls, the high-quality creator will eventually prefer a pooling equilibrium knowing that even under indistinguishable campaigns, the feedback signal helps her to attract significantly more pledges than the L-type. As established in chapter 4, we denote the willingness-to-pay of A-backers who observe identical campaigns and an informative signal, either (h,l) or (l,h), as $\overline{P}$, which constitutes the highest possible pooling price. Evidently, the H-type will prefer to pool at this price when the condition $\overline{P}(\alpha) \geq P_1(\alpha)$ is met, and $\alpha \leq \hat{\alpha}$ holds. In other words, the high-quality creator will no longer attempt to distinguish herself from the L-type when the pooling price $\overline{P}$ is higher than the price required for successful separation, and $\overline{P}$ is her preferred pooling price. For the case of $\alpha \leq \hat{\alpha}$, we can thus determine the upper boundary $\alpha \leq \alpha_2$ for the existence of a separating equilibrium by solving for α_2 in the equality $\overline{P}(\alpha_2) = P_1(\alpha_2)$. For the case of $\alpha > \hat{\alpha}$, the H-type prefers pooling at the lower price $\underline{P}$ and condition (2) has to be adjusted accordingly. Applying the same rationale, we designate the re-calculated threshold for the separating equilibrium as $\alpha \leq \hat{\alpha}_2$.[5]

Proposition 2. *(i) For* $0 < \alpha \leq \alpha_1$*, there exists a SE with* $s^* = \{(v_H, S), (v_L, S)\}$*, and A-type backers´ beliefs* $\mu_A(H|s,t) = \begin{cases} 1, & if\ s = \{(v_H, S), (v_L, S)\} \wedge t = (h, l) \\ & 0, else \end{cases}$. *(ii) For* $\alpha_1 < \alpha \leq \alpha_2$, given $\alpha \leq \hat{\alpha}$, and when using the price alone to signal quality, *there exists a SE with* $s^* = \{(P_1, S), (v_L, S)\}$ *and A-type backers´ beliefs are* $\mu_A(H|s,t) = \begin{cases} 1, & if\ s = \{(P_1, S), (v_L, S)\} \wedge t = (h, l) \\ & 0, else \end{cases}$.

Proof. See Appendix A2.

Distinct from Chakraborty and Swinney (2021), the existence of upper boundaries such as $\alpha \leq \alpha_2$ and $\alpha \leq \hat{\alpha}$ in our analysis indicates that separation may not be feasible for the H-type creator. This is driven by two aspects: first, the expected number of backers increases with (pretended) quality. Second, the L-type campaign may benefit from erroneous feedback signals with positive probability.

(ii) pooling

When the accuracy of the feedback signal further deteriorates, then the separating equilibrium breaks down. We will demonstrate that, in the range $\alpha_2 < \alpha \leq \alpha_3$, a pooling

[5] For the case of $\alpha > \hat{\alpha}$, the H-type will separate if only $\Pi_H^{sep}(P_1, S) \geq \Pi_H^{pool}(\underline{P}, S)$ applies. Let this condition be binding for $\alpha = \hat{\alpha}_2$, and the SE exists until $\alpha \leq \hat{\alpha}_2$ with $\hat{\alpha}_2 > \hat{\alpha}$.

equilibrium may exist if only both creators prefer pooling at the high price $\overline{P}$ to pooling at the lower price $\underline{P}$. As creators rely on an informative signal realization to collect a pledge at the reward price $\overline{P}$, price-cutting behavior à la Betrand does not occur. Furthermore, the H-type collects more pledges as she still benefits from the accuracy of the feedback signal. Some backers fall for the fraud of the L-type.

The remarkable existence of the pooling equilibrium relies on two conditions: first, the H-type creator prefers pooling at the higher price $\overline{P}$ to a separating strategy and to pooling at $\underline{P}$, which we explained above requires $\alpha \leq \hat{\alpha}$ to hold. Second, the H-type creator is not tempted to undercut the pooling L-type creator in prices. The remarkable stability of the pooling equilibrium is caused by the fact that price competition cannot occur for reward prices in the range $\overline{P} \geq P > \underline{P}$. To see why, consider the willingness-to-pay of A-backers based on the observed realization of the feedback signal. In the aforementioned price range, A-backers will only pledge if the signal is informative, i.e. *(h,l)* or *(l,h)*. Then A-backers are always better off to pledge to the campaign that received the positive signal *h*. As backers then make their pledge contingent on the observed signal only, undercutting the competitor´s reward price cannot be desirable. Lowering the reward price just means lower expected funding for the H-type as the expected number of backers stays constant. This constitutes the stability of the equilibrium. However, the best response to a pooling strategy of the L-type at the higher price $\overline{P}$ might still be undercutting him in prices at $\underline{P}$, thereby collecting pledges also in case of the uninformative signal. Designate the latter threshold as α_3, then a pooling outcome can only exist when $\alpha < \alpha_3$ and $\alpha < \hat{\alpha}$ applies.

Proposition 3. *For* $\alpha_2 < \alpha \leq \alpha_3 < \hat{\alpha}$, and when using the price alone to signal quality, *there exists a PE with* $s^* = \{(\overline{P}, S), (\overline{P}, S)\}$, *A-type backers´ beliefs* $\mu_A(H|s,t) = \begin{cases} \frac{(1-\alpha)^2}{(1-\alpha)^2+\alpha^2}, \; if \; t = (h,l) \\ 0.5, \; if \; t = (h,h) \vee t = (l,l) \\ \frac{\alpha^2}{(1-\alpha)^2+\alpha^2}, else \end{cases}$

and the threshold α_3 *as defined by the equality* $\Pi_H^{pool}(\overline{P}(\alpha_3), S) = \Pi_H^{sep}(\underline{P}(\alpha_3), S|P_L = \overline{P})$.

Proof. See Appendix A3.

(iii) instability in competition

If the error probability of the feedback signal increases further, then eventually both creators will engage in a Bertrand price competition. Given that the high-quality creator prefers a reward price $\underline{P}$ to pooling at the higher price $\overline{P}$, A-backers will now pledge also on the uninformative signal. An uninformative signal occurs with probability $2(1-\alpha)\alpha$, and A-backers will choose each campaign with probability 0.5 if campaigns are identical. Otherwise, they will strictly prefer the lower price. The following implication for the strategic interaction is noteworthy: each creator has a "certain market share" that can be obtained independent of the competitor´s price, as the informative, positive signal occurs with probability $(1-\alpha)^2$ for the H-type and with probability α^2 for the L-type. If a campaign receives such a signal realization, it may collect all pledges. With probability $2(1-\alpha)\alpha$, however, the signal is uninformative, and only the lowest price attracts all the pledges. In this case, undercutting the competitor´s price by a small margin ε, and ε close to zero, always attracts the additional revenue $2(1-\alpha)\alpha PN$ for a given price P and market size *N*. Distinct from the standard Bertrand competition, both creators have a guaranteed minimum profit when they focus only one the "certain market share" and ignore the price competition. Such a strategic interaction is reminiscent of price competition in targeted advertising where each seller has a certain profit when focusing on consumers that did not receive the competitor´s advertisement but also may engage in a price war for the larger group where consumers are subject to advertisements by all sellers (see Karle 2019, Siemering 2023). In such an interaction, no equilibrium in pure strategies can exist: competitors will undercut each other with price P until one creator is better off to focus on the "certain market share" at the higher price. This will incentivize the other creator to increase the reward price as well, and price competition starts all over again. Even though this goes beyond our scope of analyzing quality signaling, it is possible that the undercutting in prices leads to $P < v_L$. This will trigger a sudden market expansion, as price-oriented B-backers will now make a pledge to the cheapest campaign. However, this will not change the general nature of the mixed strategy equilibrium between the price $\underline{P}$ with a certain market share and some lower price P^U.

Proposition 4. *(i) If* $\alpha > \alpha_3$ or $\alpha > \hat{\alpha}_2 \geq \hat{\alpha}$ apply, *then no equilibrium in pure strategies exists. (ii) An equilibrium in mixed strategies can then only exist for campaigns of type* (P, S) *in the reward price range of* $\underline{P} \geq P \geq P^U$ *and* $P^U > v_L$, *if there exists a price* P^U *to satisfy the equality* $\frac{N_A}{2}(1-\alpha)^2\underline{P} + \frac{S^2}{2N_A(1-\alpha)^2\underline{P}} - S = \frac{N_A}{2}[(1-\alpha)^2 + 2\alpha(1-\alpha)]P^U + \frac{S^2}{2N_A[(1-\alpha)^2+2\alpha(1-\alpha)]P^U} - S$. *A-backers´ beliefs are* $\mu_A(H|s,t) = \begin{cases} \frac{(1-\alpha)^2}{(1-\alpha)^2+\alpha^2}, \; if\ t = (h,l) \\ 0.5, \; if\ t = (h,h) \vee t = (l,l) \\ \frac{\alpha^2}{(1-\alpha)^2+\alpha^2}, else \end{cases}$.

Proof. See Appendix A4.

Now that we have identified the equilibria of the game, the following general observation appears appropriate. If feedback on the platform is perfectly revealing the true type of the creator, then the outcome is identical to the full information result, i.e. campaigns separate at no additional costs. When the signal is imperfect but highly accurate, separation is still possible, but the H-type has to rely on the favorable signal realization which reduces her expected profit. At a certain level of signal inaccuracy, this is no longer sufficient, and the H-type has to lower the reward price in order to keep the L-type from mimicking. If the inaccuracy increases further, then under some circumstances the H-type will allow pooling and both campaigns are identical. Then, the hiqh-quality creator can extract a larger profit due to the informative signal, but fraud occurs with positive probability. When the signal deteriorates further, then such a pooling equilibrium can no longer exist: The H-type then is tempted to undercut the L-type´s reward price and further increase her profit, but once she enters into the price competition, no equilibrium in pure strategies can exist and player switch between undercutting each other and retreating on the own “certain” market share. Given such instability in competition, the frequency of fraud strongly increases. At last, if the signal is completely uncorrelated with the creator´s true type, then campaigns fail with certainty. *Fig. 2* and *Fig. 3* illustrate our findings.

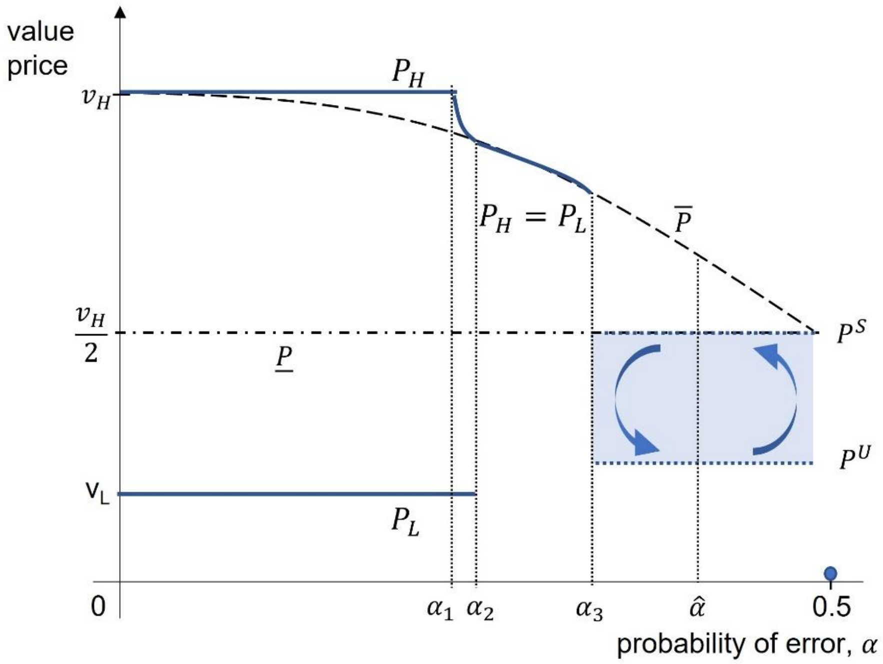

Fig. 2. Separating and pooling equilibria when signaling via reward price.

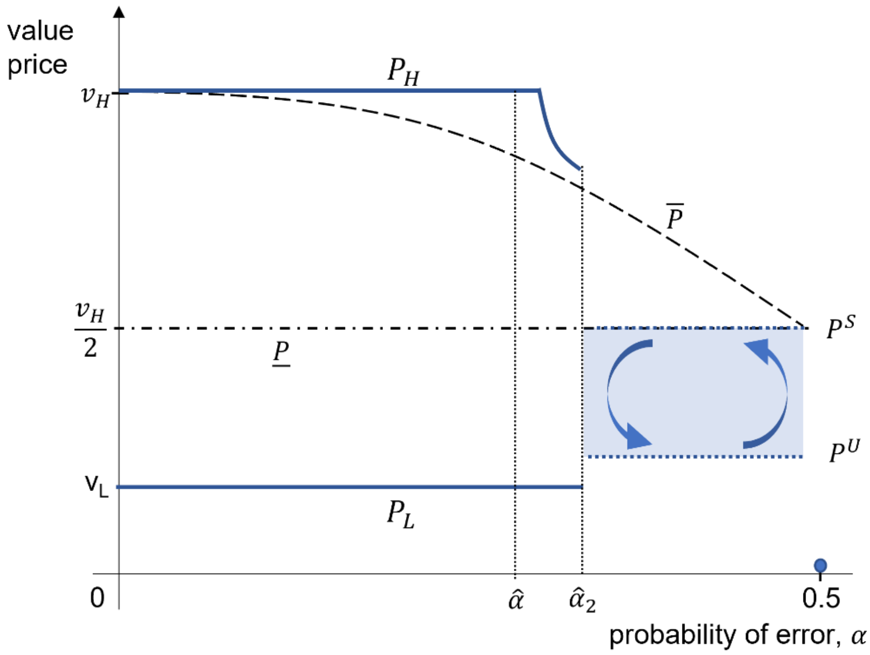

Fig. 3. Campaign design when no pooling equilibria exists.

4.4 Campaign Goal as Quality Signal

Instead of using the reward price, the high-quality creator can also signal her type via the campaign goal *C*. Then, increasing the campaign goal reduces expected profits as the campaign may fail if actual demand is rather low, but this effect is stronger for the L-type: for every market size, the high-quality creator can expect higher funding given the realizations of the feedback signal, and thus her success probability is still higher when choosing a more ambitious campaign goal. In addition, Chakraborty and Swinney (2021, p. 15) demonstrated that using the campaign goal is also preferable to signaling through the reward price, as the higher campaign goal only reduces profits in low demand states while a lower price reduces profits for all outcomes. In the following, we will thus study the case where the H-type chooses her complete information reward price, and increases only her campaign goal to signal her type.

When the high-quality creator increases her campaign goal C_H, the L-type will not pool if $\Pi_L^{pool}(v_H, C_H) \leq \Pi_L^{sep}(v_L, S)$ holds, which gives the condition

$$\int_{\frac{C_H}{\alpha^2 v_H}}^{N_A} (\alpha^2 v_H N - S) \frac{1}{N_A} dN \leq \frac{N_B}{2} v_L + \frac{S^2}{2 N_B v_L} - S \tag{4}$$

It is easy to see that $\frac{\partial \Pi_L^{pool}}{\partial C_H} < 0$ applies for $C_H > S$, i.e. a higher campaign goal reduces the L-type´s profit and may eventually prevent him from a pooling strategy. Furthermore, a higher probability of error α, a higher market size N_A or a higher value v_H make condition (4) more difficult to hold and require an even higher campaign goal C_H. From (4), we calculate the minimum campaign goal to prevent the L-type from mimicking with

$$C_H \geq \sqrt{\alpha^2 v_H \left(\alpha^2 v_H N_A^2 - N_B N_A v_L - \frac{S^2 N_A}{N_B v_L}\right) + S^2} + S = \underline{C} \tag{5}$$

Note that the expression $\alpha^2 v_H \left(\alpha^2 v_H N_A^2 - N_B N_A v_L - \frac{S^2 N_A}{N_B v_L}\right) + S^2$ is only positive for error probabilities that satisfy $\alpha > \alpha_1$, i.e. increasing the campaign goal above costs ($C_H > S$) is only required when otherwise the L-type would be able to profitably choose the pooling strategy. We established in section 4.3 that the L-type is never inclined to mimic the H-type for a high signal accuracy of $\alpha \leq \alpha_1$.

As before, separation may still not be preferable for the high-quality creator given potentially higher profits when pooling at the lower prices $\overline{P}$ and $\underline{P}$ and choosing the lower campaign goal $C_H = S$. We designate the respective pooling profits as $\Pi_H^{pool}(\overline{P}, S)$ and $\Pi_H^{pool}(\underline{P}, S)$. Then, the H-type will only separate via the campaign goal when the following condition holds

$$\int_{\frac{C_H}{(1-\alpha)^2 v_H}}^{N_A} ((1-\alpha)^2 v_H N - S) \frac{1}{N_A} dN \geq \Pi_H^{pool} \tag{6}$$

Condition (5) thus establishes the upper boundary for separation as

$$C_H \leq \sqrt{(1-\alpha)^4 v_H^2 N_A^2 - 2(1-\alpha)^2 v_H N_A \left(S + \Pi_H^{pool}\right) + S^2} + S = \overline{C} \tag{7}$$

Note that the expression in the square root is always positive if $\Pi_H(v_H, S) > \Pi_H^{pool}$, i.e. the H-type would always separate under complete information, and this is provided under the model´s assumptions. Having established a lower and an upper boundary for the campaign goal as signaling device, we find that separation via the campaign goal is not possible if $\overline{C} < \underline{C}$ applies. Using (5) and (7), and Π_H^{sep} as the H-type´s profit when separating, we can rearrange this inequality and find

Proposition 5. (i) *For $\alpha > \alpha_1$, there exists a SE with $s^* = \{(v_H, \underline{C}), (v_L, S)\}$, only if $\tilde{\Pi} = \frac{\alpha^2}{2(1-\alpha)^2}\left(\alpha^2 v_H N_A - N_B v_L - \frac{S^2}{N_B v_L}\right) + \frac{S^2}{2(1-\alpha)^2 N_A v_H} < \Pi_H^{sep} - \Pi_H^{pool}$. A-type backers´ beliefs then are $\mu_A(H|s,t) = \begin{cases} 1, & if\ s = \{(v_H, \underline{C}), (v_L, S)\} \wedge t = (h,l) \\ 0, & else \end{cases}$. (ii) Then, $\frac{\partial \tilde{\Pi}}{\partial \alpha} > 0$ holds if the L-type prefers campaign (v_H, S) to (v_L, S) whenever the H-type does not signal her type.*

Proposition 5 shows that the H-type will only choose separation via the campaign goal when generating this costly signal is still preferable to accepting a pooling outcome, i.e. the difference in profits between the separating equilibrium and the pooling equilibrium is sufficiently high. Otherwise, a separating equilibrium cannot be obtained. Note that this result is particularly sensitive to the signal accuracy: the higher the probability of erroneous feedback, the more likely it is that separation is no longer feasible. Again, the failure to achieve a separating equilibrium implies that fraud cannot be ruled out by signaling in CF-campaigns.

5. DISCUSSION OF POTENTIAL REMEDIES

In the previous section, we established that a separating equilibrium will fail if feedback accuracy is sufficiently low. This gives rise to fraudulent behavior by creators such as empty promises or deceptive statements about the characteristics and usefulness of their product. Even though competent, honest creators may still be successful to raise sufficient funding when campaigns compete, the occurrence of fraud clearly diminishes the economic value of the CF platform and potentially endangers its business model as intermediary. In the following, we will thus discuss several remedies that can be applied by platforms to counter crowdfunding scams and facilitate truthful signaling of quality. Table 1 provides an overview.

Category	Solution	Handling by Platforms
Legal	Liability for insufficient quality	Kickstarter: "*It's the project creator's responsibility to complete their project. Kickstarter doesn't step into the creative process itself or manage the fulfillment and shipment of rewards.*" Indiegogo: "*Campaign Owners bear sole responsibility for the delivery of Perks and for the offering of any refunds outside Our Refund Policy." (i.e. refunding only before campaign ends)*
Pricing	Unconditional fees	
Pricing	Conditional fees	Kickstarter and Indiegogo charge five percent of the collected funds when disbursed to the campaign owner
Policy	Campaign requirements	Indiegogo: "We do not screen Campaigns or endorse any User Content on Our site. Likewise, Indiegogo does not undertake any duty to investigate or guarantee the truthfulness of any claims made by Campaign Owners. You should evaluate a Campaign's statements before choosing to back the Campaign."

Table 1. Overview of remedies by the platform.

A well-established remedy to overcome adverse selection is the enforcement of warranty rights and liability rules against the seller. While liability may deter wrongdoing per se, such a policy also improves the ability of the seller of a high-quality product to distinguish herself from the low-type: given that a high-quality product will lead to less additional costs through defects and damages than a low-quality product, and these costs may exceed savings from producing a low quality, the seller of the high-quality product can signal her type via the price. At first glance, the situation is similar for the case of crowdfunding. If low-type creators can be made liable for fraudulent claims or misleading product statements, this increases the amount of required funding to make positive profits. This becomes even more pronounced in our model where the L-type creator incurs the same fixed costs for production as the H-type although he produces the inferior product. If the L-type were also liable to compensate deceived backers, this would even create a cost disadvantage and require a higher campaign goal. As the L-type creator wants to mimic the H-type campaign parameters, the campaign goal has to be too low to cover these additional costs. Distinct from standard scenarios of consumer protection, however, this incentive mechanism is weakened in crowdfunding for two reasons: first, the expected liability costs are only effective on the L-type in low demand states, i.e. when the campaign is barely successful but total funds are insufficient to start production and fulfill all expected liability claims. In high demand states, however, the collected funds may be more than sufficient to cover additional legal risks. It is essential to bear in mind that such risks are typically small value claims which are often not pursued by the claimant. Second, even if demand turns out to be insufficient, there is little risk for the fraudulent creator. If the campaign fails, profits are zero as neither funding or production occurred. If the campaign is barely successful but funding is insufficient to cover all costs, the creator may claim to be unable to fulfil its obligation to start production and simply offer to refund the (unconsumed) pledges. Platforms are often unable to enforce the obligation of creators to complete a project when campaigns are successful. Gutiérezz-Urtiega/ Sáez-Lacave (2017) demonstrate that backers and creators effectively work under a contract that does not penalize the creator´s failure to perform. Ganatra (2015, p. 1442) also points out that platforms such as kickstarter should implement proper regulation and oversight as gatekeepers (see also Cuming et al. 2023) but do little except suggesting their backers to take legal recourse on their own. In the world of our model, we find that fraudulent campaigns under liability rules thus turn into a unique *bet on high market demand*, and creators can avoid liability and sneak away if the bet fails. In other words, this commitment problem thus ensures that expected profits of fraudulent creator can never be negative, which diminishes the value of liability rules for the ability of the H-type to signal her type.

A second possible approach lies in the pricing policy of CF platforms. Trivially, fees paid to the intermediary affect creators´ profits and thus potentially facilitate incentive compatibility. Platform predominantly implement conditional fee schemes, that is the fee, e.g., a certain percentage of the funds collected, is to be paid to the platform contingent on the success of the campaign.[6] Again, this does not solve the commitment problem, as the creator can observe the realized market demand before starting the production of the fraudulent product and profits can never be negative. Nevertheless, the impact of conditional fees on creator´s expected profit under the "All-or-Nothing"-mechanism is particularly limited, as no fees are charged when the campaign fails to meet its goal. This would change for the case of unconditional fees which are paid by creators upfront and are irrespective of the collected funds. This would particularly increase the risk to fraudulent L-type creators in low demand states and could thus improve the H-type creator´s ability to signal her type. However, unconditional fees mean a significant financial burden on all creators and may prove to be incompatible to the nature of (non-professional) crowdfunding. Scaring of potentially sincere campaigns is also not in the interest of CF platforms who seek to attract users and benefit from further developing their network effects.

A third remedy against adverse selection could be stricter requirements for launching campaigns on the platform. It is straightforward to see that requirements such as the development (and testing) of a prototype, transparent documentation or the external evaluation of a proof of

[6] Platforms as kickstarter and indiegogo charge a five percent fee on total funds collected. Indiegogo also offers the 'keep-it-all'-option to creators, so the fees is charged irrespective of meeting the campaign goal.

concept will rule out some fraudulent or unfit creators to launch campaigns on the platform. Following our game-theoretic model, such stricter requirements also impose additional costs on creators, but such costs are substantially higher for the L-type creator who chooses to mimic a high-quality product. Furthermore, such pre-campaign expenses are sunk when campaigns eventually start, thus they increase the financial risk for L-type creators even if demand turns out to be too low to carry out the fraud and dishonest creators would prefer to sneak away. It appears that such a strategy would be less harmful to sincere creators of potentially high-quality products and thus more compatible with the CF platform business model. Compared to the management of small value claims and the development of a platform arbitration mechanism, this also creates less additional expenses for the platform. However, lawmakers may be required to further incentivize platforms as digital gatekeepers to take over that responsibility.

6. CONCLUDING REMARKS

We apply a game-theoretic model of reward-based crowdfunding to study adverse selection problems when campaign owners compete in prices. Distinct from the previous literature, we find that a separation equilibrium may not exist if the accuracy of an informative signal about the creator´s true type is too low, or a fraudulent creator can expect to attract many more backers when mimicking the campaign for a high-quality product. Competition becomes unstable for low values of signal accuracy and campaign owners randomize between withdrawing to a safe market niche and price competition. The campaign owner of the high-quality product has two campaign variables to signal her type to backers, the reward price, and the campaign goal. Only signaling via the reward price may allow a pooling equilibrium of identical campaigns without the incentive to undercut the competitor´s price.

The lack of enforceable commitment of successful campaign owners to carry out their project weakens the impact of liability rules as creators can choose to refund and withdraw whenever realized funds appear to low. Lawmakers should incentivize crowdfunding platforms to impose further requirements for launching a campaign, such as testing of a prototype or certified proof of concepts. As this creates sunk costs for campaign owners, the commitment problem does not apply, and high-type creators should be better able to cope with elevated standards than fraudulent ones.

A1 PROOF OF PROPOSITION 1

(i) If the true type is perfectly revealed, the H-type creator´s profit is $\Pi_H(p_H; S) = \int_{\frac{S}{p_H}}^{N_A} (p_H N - S) \frac{1}{N_A} dN = \frac{N_A}{2} p_H + \frac{S^2}{2N_A p_H} - S$. Clearly, the price must meet the constraint $p_H \leq v_H$ in order to collect pledges from A-backers. Since $\frac{\partial \Pi}{\partial p} = \frac{N_A}{2}\left(1 - \frac{S^2}{(N_A P)^2}\right) > 0$ holds under any acceptable price P with $N_A P \geq S$, the H-type chooses $p_H = v_H$. Similarly, this reasoning applies to the L-type who chooses $p_L = v_L$. (ii) When the signal is completely uninformative, backers know the probability of choosing the H-type campaign is 0.5. A reward price $p > \frac{v_H}{2}$ is never successful. For $p \leq \frac{v_H}{2}$, uninformed A-backers choose randomly when prices are equal, and otherwise prefer the lower price. Note that the L-type, given identical production costs, will always attempt to undercut the H-type when expected profits are higher in the high-quality market segment. If the price falls further, $p \leq v_L$, B-backers will also choose the campaign with the lowest price. Thus, the expected market size expands to $N_A + N_B$. Undercutting the competitor is profit-maximizing, as in a Bertrand price competition, until the price reaches $p = \frac{S}{N_A + N_B}$. This is the lowest possible price for which a campaign, if it marginally undercuts the competitor, has a positive probability of campaign success. Given this price of the competing campaign, a creator who chooses a higher reward price will attract no pledges at all, choosing a lower price will also mean zero profit as the campaign fails with certainty to meet the campaign goal. More generally, for a price $p \leq \frac{S}{N_A + N_B}$, any price of the competing campaign yields zero profits and is a best response. Thus, $s^* = \left\{\left(p_H \leq \frac{S}{N_A + N_B}, S\right), \left(p_L \leq \frac{S}{N_A + N_B}, S\right)\right\}$ is a combination of best responses. This pricing implies certain campaign failure, as no creator can collect sufficient pledges: for $p_H = p_L = \frac{S}{N_A+N_B}$, each creator only receives half of the required revenue, for any lower price, it is impossible to cover the fixed cost S even if the market were of size $N_A + N_B$. ■

A2 PROOF OF PROPOSITION 2

The L-type creator will not pool if $\Pi_L^{pool}(P,S) \leq \Pi_L^{sep}(v_L,S)$ applies, which yields

$$\int_{\frac{S}{\alpha^2 P}}^{N_A} (\alpha^2 PN - S)\frac{1}{N_A} dN \leq \frac{N_B}{2} v_L + \frac{S^2}{2N_B v_L} - S \tag{2}$$

Using (2) and solving for P, we find the required reward price P must hold to

$$P \leq \frac{\sqrt{\left(\frac{N_B}{2}v_L+\frac{S^2}{2N_B v_L}\right)^2 - S^2} + \frac{N_B}{2}v_L+\frac{S^2}{2N_B v_L}}{\alpha^2 N_A} = P_1 \tag{3}$$

For $v_H \leq P_1$, we insert $v_H = P$ and solve for α. This gives the threshold $\alpha \leq \sqrt{\frac{\sqrt{\left(\frac{N_B}{2}v_L+\frac{S^2}{2N_B v_L}\right)^2 - S^2} + \frac{N_B}{2}v_L+\frac{S^2}{2N_B v_L}}{v_H N_A}} = \alpha_1$. Note that $\frac{N_B}{2} v_L + \frac{S^2}{2N_B v_L} > S$ always applies when a campaign for the B-Backers is profitable for the L-type. The profit for the separating H-type then gives $\Pi_H^{sep}(v_H,S) = \frac{N_A}{2}(1-\alpha)^2 v_H + \frac{S^2}{2N_A(1-\alpha)^2 v_H} - S$, and this is lower than her. complete-information profit. For $v_H > P_1$, her profit further decreases to $\Pi_H^{sep}(P_1,S) = \frac{N_A}{2}(1-\alpha)^2 P_1 + \frac{S^2}{2N_A(1-\alpha)^2 P_1} - S$ and it may be lower than her profit in a pooling solution. When campaigns pool, A-backers pledge to the campaign where h is observed if the reward price does not exceed the expected willingness-to-pay, i.e. $p \leq \frac{(1-\alpha)^2}{(1-\alpha)^2+\alpha^2} v_H = \overline{P}$ applies.

The H-type will thus still prefer to separate at the price P_1 if only $\int_{\frac{S}{(1-\alpha)^2 P_1}}^{N_A} \left((1-\alpha)^2 P_1 N - S\right)\frac{1}{N_A} dN > \int_{\frac{S}{(1-\alpha)^2 \overline{P}}}^{N_A} \left((1-\alpha)^2 \overline{P} N - S\right)\frac{1}{N_A} dN$ holds, which clearly simplifies to $P_1 > \overline{P}$. This implies that both campaigns may pool for $P_1 \leq \overline{P}$. We find the threshold $\alpha = \alpha_2 < 0.5$ for the H-type where she is indifferent between pooling and separating by equating $P_1(\alpha_2) = \overline{P}(\alpha_2)$, if it exists. Note that $\frac{\partial P_1}{\partial \alpha} < 0$ and $\frac{\partial \overline{P}}{\partial \alpha} < 0$ apply, thus the threshold may not exist if N_A is relatively small. Then separation is always possible for the H-type.

For the case of $\alpha \leq \hat{\alpha}$, we can thus determine the upper boundary $\alpha \leq \alpha_2$ for the existence of a separating equilibrium by solving for α_2 in the equality $\overline{P}(\alpha_2) = P_1(\alpha_2)$. For the case of $\alpha > \hat{\alpha}$, the H-type will separate if only $\Pi_H^{sep}(P_1, S) \geq \Pi_H^{pool}(\underline{P}, S)$ applies. Then, $\int_{\frac{S}{(1-\alpha)^2 P_1}}^{N_A} \left((1-\alpha)^2 P_1 N - S\right)\frac{1}{N_A} dN = \int_{\frac{S}{((1-\alpha)^2+\alpha(1-\alpha))\underline{P}}}^{N_A} \left(\left((1-\alpha)^2 + \alpha(1-\alpha)\right)\underline{P} N - S\right)\frac{1}{N_A} dN$ holds. Let this condition be binding for $\alpha = \hat{\alpha}_2$, and the SE exists until $\alpha \leq \hat{\alpha}_2$ with $\hat{\alpha}_2 > \hat{\alpha}$.■

A3 PROOF OF PROPOSITION 3

Following Proposition 2, the H-type will not separate if $\alpha > \alpha_2$, i.e. she prefers pooling at price $\overline{P}$ to separation at price P_1. In such a pooling equilibrium, A-backers only pledge on the positive signal realization *h*. However, the strategy $(\overline{P}, S)$ is only part of an equilibrium if the H-type has no incentive to deviate. Undercutting the competitor in the range $\overline{P} \geq P > \underline{P}$ is never favorable to her, as she collects the same number of pledges but at a lower price: either way, A-backers pledge with probability $(1-\alpha)^2$. Undercutting the competitor in the lower range $P \leq \underline{P}$, however, leads to more pledges as A-backers will then also pledge in case of the uninformative signal. Pledges are then collected with the higher probability $(1-\alpha)^2+2\alpha(1-\alpha)$, but at the lower price. The H-type prefers pooling at the higher price only if $\int_{\frac{S}{(1-\alpha)^2\overline{P}}}^{N_A}\left((1-\alpha)^2\overline{P}N-S\right)\frac{1}{N_A}dN \geq \int_{\frac{S}{[(1-\alpha)^2+2\alpha(1-\alpha)]\underline{P}}}^{N_A}\left([(1-\alpha)^2+2\alpha(1-\alpha)]\underline{P}N-S\right)\frac{1}{N_A}dN$ holds. Let this condition by binding for $\alpha=\alpha_3$, then a pooling equilibrium exists in the range $\alpha_2<\alpha\leq\alpha_3$ if $\alpha_2<0.5$ and $\alpha\leq\hat{\alpha}$ applies. ■

A4 PROOF OF PROPOSITION 4

(i) If condition $\alpha>\alpha_3$ holds, the H-type creator prefers undercutting the competitor at price $\underline{P}$ to a pooling equilibrium at $\overline{P}$. If condition $\alpha>\hat{\alpha}_2\geq\hat{\alpha}$ holds instead, i.e. the H-type creator prefers undercutting the competitor at price $\underline{P}$ to a separating equilibrium. The following consideration applies: a creator has a "certain profit" if it charges the price $\underline{P}$, irrespective of its competitor, and then collects pledges only on the favorable signal realizations (h,l). As the H-type has a higher probability to attain such a signal, her certain profit Π_H^S is defined by $\Pi_H^S=\frac{N_A}{2}(1-\alpha)^2\underline{P}+\frac{S^2}{2N_A(1-\alpha)^2\underline{P}}-S$. However, price $\underline{P}$ cannot be an equilibrium. It is easy to see that undercutting the competitor is then preferable due to the 'market extension'-effect, i.e. backers who then also pledge on the uninformative signal. The following condition clearly holds if a price P of the L-type is marginally undercut by $P-\varepsilon$: $[(1-\alpha)^2+2(1-\alpha)\alpha](P-\varepsilon)N>(1-\alpha)^2PN \Leftrightarrow \varepsilon<\frac{2(1-\alpha)\alpha}{[(1-\alpha)^2+2(1-\alpha)\alpha]}P>0$. A similar reasoning applies for the L-type. (ii) Starting from $\underline{P}$, creators will seek to undercut each other until the profit of the H-type falls to the certain profit Π_H^S even when offering the lower price P^U. This lower boundary P^U can be found by solving the equation $\frac{N_A}{2}(1-\alpha)^2\underline{P}+\frac{S^2}{2N_A(1-\alpha)^2\underline{P}}-$

$S = \frac{N_A}{2}[(1-\alpha)^2 + 2\alpha(1-\alpha)]P^U + \frac{S^2}{2N_A[(1-\alpha)^2+2\alpha(1-\alpha)]P^U} - S$ for P^U. If this price is marginally undercut by the competitor, the H-type is strictly better off by raising the price back to $\underline{P}$. Consequently, no equilibrium in pure strategies exists. ■

A5 PROOF OF PROPOSITION 5

(i) Separation is impossible if only $\overline{C} < \underline{C}$ applies. Using (5) and (7), we find $\alpha^2 v_H \left(\alpha^2 v_H N_A^2 - N_A N_B v_L - \frac{N_A S^2}{N_B v_L}\right) > (1-\alpha)^4 (v_H N_A)^2 - 2(1-\alpha)^2 v_H N_A \left(S + \Pi_H^{pool}\right)$. We can rearrange the right side of the equation to $2(1-\alpha)^2 v_H N_A \left(\frac{(1-\alpha)^2 v_H N_A}{2} - \left(S + \Pi_H^{pool}\right)\right)$. Using $\Pi_H^{sep} = (1-\alpha)^2 \frac{N_A}{2} v_H + \frac{S^2}{2(1-\alpha)^2 N_A v_H} - S$, we can simplify to $2(1-\alpha)^2 v_H N_A \left(\Pi_H^{sep} - \frac{S^2}{2(1-\alpha)^2 N_A v_H} - \Pi_H^{pool}\right)$. For the inequality, this then gives $\widetilde{\Pi} = \frac{\alpha^2}{2(1-\alpha)^2}\left(\alpha^2 v_H N_A - N_B v_L - \frac{S^2}{N_B v_L}\right) + \frac{S^2}{2(1-\alpha)^2 N_A v_H} \geq \Pi_H^{sep} - \Pi_H^{pool}$. (ii) $\frac{\partial \widetilde{\Pi}}{\partial \alpha} = \frac{\left(2\alpha^3 v_H N_A - \alpha N_B v_L - \alpha \frac{S^2}{N_B v_L}\right) 4(1-\alpha)^2 + \left(\alpha^4 v_H N_A - \alpha^2 N_B v_L - \alpha^2 \frac{S^2}{N_B v_L}\right) 4(1-\alpha)}{4(1-\alpha)^4} + \frac{1}{(1-\alpha)^3}\frac{S^2}{N_A v_H}$. This can be simplified to $\frac{2N_A v_H \left(\alpha\left(\alpha^2 v_H N_A - (0.5 N_B v_L + \frac{S^2}{2N_B v_L})\right)(1-\alpha) + \alpha^2\left(0.5\alpha^2 v_H N_A - (0.5 N_B v_L + \frac{S^2}{2N_B v_L})\right)\right) + S^2}{N_A v_H (1-\alpha)^3}$. Note that $\Pi_L^{sep} = 0.5 N_B v_L + \frac{S^2}{2N_B v_L} - S$, so we can rearrange to $\frac{\partial \widetilde{\Pi}}{\partial \alpha} = \frac{2N_A v_H \left(\alpha\left(\alpha^2 v_H N_A - (\Pi_L^{sep} + S)\right)(1-\alpha) + \alpha^2\left(0.5\alpha^2 v_H N_A - (\Pi_L^{sep} + S)\right)\right) + S^2}{N_A v_H (1-\alpha)^3}$. This term will be positive if $\alpha\left(\alpha^2 v_H N_A - (\Pi_L^{sep} + S)\right)(1-\alpha) + \alpha^2\left(0.5\alpha^2 v_H N_A - (\Pi_L^{sep} + S)\right) + \frac{S^2}{2N_A v_H} > 0$, which simplifies further to $\left(\alpha^2 v_H N_A - S - \Pi_L^{sep}\right)(1-\alpha) + \alpha\left(\Pi_L^{pool} - \Pi_L^{sep}\right) > 0$. For the right summand, $\Pi_L^{pool} > \Pi_L^{sep}$ must apply, otherwise the L-type would never attempt to pool. For the left summand, $\alpha^2 v_H N_A - S - \Pi_L^{sep} > 0$ must hold, as otherwise the maximum possible funding volume in the high-quality market, $v_H N_A$, would not be sufficient to incentivize the L-type to choose a pooling strategy. Thus, $\frac{\partial \widetilde{\Pi}}{\partial \alpha} > 0$. ■

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