Entrepreneurial Motivation and Crowdfunding: The Signaling Value of Product Location and Funding Goal

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Abstract

Advancements in information technology enable new business models and new market mechanisms. Online crowdfunding is one such new mechanism, through which entrepreneurs can advertise their potential products and attract investment from the public. Four key features of online crowdfunding motivate our study: (i) entrepreneurs produce the products after their funding goals are reached; (ii) entrepreneurs determine product quality after receiving funding from backers; (iii) entrepreneurs have heterogeneous motivations. Some (product-driven entrepreneurs) value more about product location and quality than others (profit-driven entrepreneurs); and (iv) entrepreneurs pay commission to the platform. In this study, we advance the existing theory on online crowdfunding markets by analyzing a signaling game between heterogeneously motivated entrepreneurs and backers. We show that heterogeneously motivated entrepreneurs can signal their commitment to quality through product location choices and funding goals. We further analyze how the commission rate of the platform can affect entrepreneurs' and backers' decisions, and so the platform's future reputation for project quality. Finally, we identify the optimal commission rate of the platform.

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1 Introduction

Recent developments in information technology offer a plethora of new opportunities for entrepreneurs, and have fundamentally changed the business ecosystem for startups. One such innovation is the crowdfunding platform. The business model of the reward-based crowdfunding makes it possible for entrepreneurs to access investment from "the crowd."[1] As an alternative financing channel, reward-based crowdfunding platforms have supported innovative entrepreneurial ideas and ventures over the last decade, see Schwienbacher and Larralde (2010). One such success story from Kickstarter, one of the most popular crowdfunding platform, is the Pebble time smart watch. Pebble time was launched on April 11, 2012, at Kickstarter. The funding goal of Pebble time was 100,000 US dollars.[2] However, within 2 hours of going live, the project had met its funding goal, and raised 10.3 million US dollars by the end of the campaign (May 18, 2012). The first wave of product delivery started in January 2013. It was sold to Fitbit in June 2018 and was recently acquired by Google.

Four features of reward-based crowdfunding motivate our study: (i) entrepreneurs set their funding goals first and then produce the product after the funding goals are reached; (ii) entrepreneurs determine product quality after receiving funding from backers; (iii) entrepreneurs have heterogeneous motivations. Some value more on product location and quality than the others; (iv) entrepreneurs pay commission to the platform. The first two features indicate backers in crowdfunding markets face a unique information asymmetry problem—product quality is determined after their investments.

[1] Rewards-based crowdfunding is a type of small-business financing in which entrepreneurs request financial donations from individuals in return for a product or service.

[2] Launching a Kickstarter project requires setting a funding goal. A project becomes successful if the funding goal is reached before the campaign ends. Then the founder of the successful project can access the raised funding as soon as the campaign ends.

The third feature is that entrepreneurs have heterogeneous motivations—some value more on product location and quality than the others. A vast literature on entrepreneurship suggests that entrepreneurs value not only profit or market size, but also product features such as product location and quality (see Kerr et al. (2018) and Rose-Ackerman (1996)). We call those who value relatively more on product location and quality product-driven entrepreneurs and those who value relatively more on profit profit-driven entrepreneurs. Entrepreneurs can have strong preferences on product location and quality for various reasons. Some initiated their projects as superusers of the product and aimed to produce the ideal product with the desired product location and quality to fit with a specific goal in mind. For instance, the founder of the Pebble time is an engineer who was racking up kilometers every day on his bicycle. So he initiated the project to help people answer phone calls on their wrist without pulling out cell phones. Another example is LIV, a successfully crowdfunded project of classical mechanical watches on Kickstarter. It is founded by one of the family watchmakers from Switzerland. The founder aims to continue producing timepieces of the utmost quality and craftsmanship to compete with the watches with modern technology. At the same time, some entrepreneurs may not have a strong preference over product location and quality but value more on targeting a broader customer base to earn as much profit as possible.

The information asymmetry problem becomes particularly interesting when a platform has both product-driven and profit-driven entrepreneurs. In particular, backers always prefer high-quality products given the same product locations. But, at the same time, they cannot directly observe entrepreneurs' preferences for product location and quality. This leads to a signaling game between heterogeneously motivated entrepreneurs and backers. Product-driven entrepreneurs can signal their motivations through product locations and funding goals. It is because product-driven entrepreneurs exert more effort to improve product quality and are also more stubborn about product location. As a result, their costs of implementing high-quality products are high, so they need to set higher funding goals to cover their costs. Meanwhile, profit-driven entrepreneurs have incentives to mimic product-driven entrepreneurs' product locations to appear product-driven. When product-driven entrepreneurs' product location is far away from the median backer's ideal location, the profit-driven entrepreneurs have to sacrifice too much market share to appear to be product-driven entrepreneurs. In this case, product-driven entrepreneurs separate from the profit-driven ones in equilibrium.

Finally, the fourth feature is that entrepreneurs pay commission to the platform. Commissions increase entrepreneurs' cost of raising funds on a crowdfunding platform, thereby effectively increasing the funding goals of entrepreneurs and thus forcing the entrepreneurs to earn higher profits to cover the costs. As a result, the platform's commission policy potentially influences the equilibrium behavior of entrepreneurs and backers, including entrepreneurs' choices of product location, quality, funding goal, and backers' investment decisions. We further note that platform not only cares about current commission revenue obtained from the entrepreneurs, but also its future reputation which affect its future customer base and future commission. Therefore, the platform faces a trade-off between current commission revenue and future reputation.

The above features naturally lead to our research questions: first, given the platform's commission policy, what is the equilibrium outcome of the signaling game between heterogeneously motivated entrepreneurs and backers? Second, what is the platform's optimal commission policy? To this end, we build a spatial competition model wherein two entrepreneurs (who can be product-driven or profit-driven) compete for funding on and pay commission to a crowdfunding platform. Backers with heterogeneous preferences on product locations locate along a continuum; the platform sets commission policy to maximize its expected current and future revenue.

In our model, crowdfunding campaign announcements play dual roles: (i) as a commitment to product locations and funding goals (ii) as signals about entrepreneurs' motivations. This duality induces a signaling game, and what drives the game is the fact that product-driven entrepreneurs care more about ideal product locations and, exert more effort to produce relatively high-quality products if funded. Thus, holding product locations equal, backers prefer investing in a product-driven entrepreneur to investing in a profit-driven one. This endogenous preference of backers creates incentives for product-driven entrepreneurs to separate or profit-driven entrepreneurs to mimic. That is, product-driven entrepreneurs wish to separate from profit-driven entrepreneurs and signal their types to backers. In contrast, profit-driven entrepreneurs seek to mimic product-driven entrepreneurs and appear to be product-driven. This strategic interaction iterates continuously, such that the equilibrium behavior differs significantly from the case when entrepreneurs' motivations are homogeneous. Furthermore, in our model, the platform sets an optimal commission policy based on the trade-off between current commission revenue and future reputation, which is determined by the average product quality of crowdfunded projects on the platform. Since the commission policy affects entrepreneurs' cost and project funding goal, it affects entrepreneurs' strategies and incentives to separate or mimic.

We characterize all perfect Bayesian equilibria under D1 refinement and solve the optimal commission rate for the platform. We find that the distance between the entrepreneur's ideal product location and the median backer's ideal product location determines the existence of pooling, separating, or hybrid equilibrium. Interestingly, an increase in the commission rate will first increase and then decrease the platform's reputation for quality. As a result, it is optimal for the platform to charge a moderate commission fee as long as it cares sufficiently for future reputation. When the commission rate is lower than the optimal, an increase in the commission would increase entrepreneurs' funding goals and so forces the product-driven entrepreneurs to choose locations close to the center to obtain a higher market share. Thus, the average quality and reputation of the platform become higher. On the other hand, when the commission rate is higher than the optimal, the cost of creating a crowdfunding project becomes too high for a product-driven entrepreneur to enter. Without product-driven entrepreneurs creating a project, the platform's reputation for quality decreases sharply.

2 Related Literature

First, our work contributes to the theoretical literature of crowdfunding. Most of the literature emphasizes a single entrepreneur's decision problem and studies the optimal strategies and associated consequences for backers and crowdfunding platforms. For instance, Strausz (2017) and Chemla and Tinn (2019) use mechanism design approach to address a single entrepreneur's moral hazard problem when there is demand uncertainty.[3] Abstracting away from moral hazard, Ellman and Hurkens (2019) focuses on whether and how an entrepreneur can use crowdfunding as a tool of price discrimination and market testing. Roma et al. (2018) views crowdfunding as an early stage of venture capital investment—crowdfunding campaign sends a signal about the project to the venture capitalists. The paper discusses the entrepreneur's optimal strategy of designing crowdfunding campaign. Hu et al. (2015) studies the optimal pricing and product strategy of the entrepreneur on a crowdfunding platform facing heterogeneous backers. By contrast, our paper focuses on crowdfunding markets with duopolistic competition, and entrepreneurs' moral hazard problems are induced by their heterogeneous motivations. Moreover, our paper introduces an active role of the platform. That is, the platform can strategically choose its commission fee which affects entrepreneurs' and backers' choices.

Meanwhile, an extensive literature of crowdfunding discuss how entrepreneurs' characteristics campaign strategies and platform policies influence crowdfunding outcomes. For instance, Mollick (2014) studies how project quality and entrepreneurs' social network size influences crowdfunding performance. Agrawal et al. (2015) studies the relationship between physical distance to entrepreneurs' location and crowdfunding outcomes. Burtch et al. (2016) studies how information hiding of early contributors affects crowdfunding performance. Yang et al. (2020) studies the effect of reward limits on crowdfunding performance. Kim et al.

[3]Strausz (2017) finds the crowdfunding platform should withhold demand information and defer the payment of the raised funding to the entrepreneur. Chemla and Tinn (2019) argues that entrepreneurs' learning of consumer demand through crowdfunding mechanism effectively alleviates the entrepreneur's moral hazard problem.

(2022) addresses how risk disclosure policies of crowdfunding markets affect backers' crowdfunding decisions through reducing information asymmetry.

Moreover, our study relates to the literature studying duopolistic competition in a spatial setting. The most related ones are Bontems et al. (2005) and Vettas (1999), which considers a signaling game in the spatial competition setting. In Bontems et al. (2005), duopolistic firms use price and dissipative advertising as signals for product quality; product quality is exogenously given and uncorrelated with product location. Vettas (1999) discusses in its extended model, two sequentially entered firms may use location to signal product quality. In the model, quality of the firm is exogenously given; only the first entrant has private information of the quality and the second entrant's quality is fixed. The analysis focuses on the existence of a separating equilibrium rather than a full characterization of the equilibrium. By contrast, in our paper, both entrepreneurs have private information about their motivations; product quality is endogenously chosen by each entrepreneur and is correlated with product location through the entrepreneur's motivation; and so product locations and funding goals jointly serve as signals for the entrepreneurs' motivation. We fully characterize the equilibrium. By doing so, we can discuss factors (such as platform's commission policy) that influence equilibrium outcome and generate managerial implications. Hotz and Xiao (2013) considers the scenario that consumers have different preference weights on location and quality and discusses the duopolistic firms' optimal information disclosure about their product locations. Pu et al. (2017) studies online sellers' strategies of quality misrepresentation and pricing in a spatial competition setting and discusses the influence of platform policies on sellers' quality misrepresentation. Other studies using the spatial competition model choose to abstract away from the product's vertical attribute of the product—quality. For instance, Janssen and Teteryatnikova (2016) addresses, in a spatial competition model, whether it is optimal for the firm to disclose its own and/or its rival's product location and/or price to consumers. Anderson Jr et al. (2013) discusses how spatial competition between video game platforms influences platforms' investment strategies and performance. Ho et al.

(2017) studies the impact of spatial competition between online cashback platforms on the cashback rate and consumers' choices. Choudhary et al. (2018) builds a model based on a spatial competition model with two competing firms to study firms' incentive to invest in Information Technology (IT) given the risk of IT implementation failure.

Finally, our paper relates to the literature of signaling on product quality (which does not use spatial competition models). For instance, Kihlstrom and Riordan (1984) presents a model in which firms as competitive price takers use dissipative advertising to signal quality, and find that advertising alone is not informative about quality, i.e., a separating equilibrium does not exist. Milgrom and Roberts (1986) establishes the existence of a separating equilibrium in an alternative setting in which a monopoly firm jointly uses advertising and price to serve as signals of quality. In these models, advertising alone is not informative about quality, and the most desirable equilibrium (for consumers) is a separating equilibrium, in which advertising and/or price are informative about quality of the product. See Bagwell (2007) for a comprehensive survey on the classical study on this topic. Different from the literature, our model introduces heterogeneity in motivation and allows competition between entrepreneurs. We find that even when firms are competitive price-takers, the product locations and funding goals are informative about the entrepreneurs' motivations and product quality.

3 Model

Consider a reward-based crowdfunding platform on which two entrepreneurs compete for funding from backers.

Backers. A unit mass of backers come to the crowdfunding platform and make investment choices. Backers care about product location and quality. Each backer has an ideal product location b, which is assumed to be uniformly distributed in $[-1, 1]$. We slightly abuse notation and index backers by b. Each backer prefers the highest quality. We assume quality belongs to [0,1]. Each backer gains I utils from investing in a project with an ideal product location and the highest quality. If backer b invests in a project with product location $\hat{x}$, quality $\hat{q}$, the backer incur a utility loss from investing in a project with less favorable product location $(b - \hat{x})^2$ and a utility loss from less favorable quality $(1 - \hat{q})^2$. Each backer pays the price p for the investment. Thus, the payoff of backer b is[4]

$$u_b(\hat{x}, \hat{q}; b) = I - \left[(b - \hat{x})^2 + (1 - \hat{q})^2\right] - p.$$

We assume $I > 5+p$, which guarantees that u_b is always positive. If a backer does not invest, then the payoff is normalized to be zero. This assumption induces that backers will always invest in one of the entrepreneurs. It simplifies backers' decision problems to choose which entrepreneur to invest in, which facilitates our analysis but will not affect the qualitative nature of our results.[5]

Entrepreneurs. Two entrepreneurs $e \in \{A, B\}$ enter the platform to create projects to attract funding from the backers. Entrepreneurs have heterogeneous motivations, which we modeled as their *types*. Each entrepreneur has a type $t \in \{0, 1\}$. When $t = 0$, the entrepreneur only cares profit, we call type 0 entrepreneur *profit-driven*. When $t = 1$, the entrepreneur also cares about the product location and quality, we call type 1 entrepreneur *product-driven*. Each entrepreneur's type is drawn from the same i.i.d. distribution: entrepreneur $e \in \{A, B\}$ is profit-driven (type 0) with probability $\lambda \in (0, 1)$ and product-driven (type 1) with probability $1 - \lambda$.[6] Each entrepreneur e knows its own type; backers and the opponent entrepreneur $e' \neq e$ do not know entrepreneur e's type, but they know the distribution—the probability of entrepreneur e being profit-driven is λ.

[4]For ease, we normalize the (marginal) misfit cost to 1.

[5]If $I > 5+p$ is violated, we would need an extra condition to ensure the investor chooses to invest in one of the projects, under which our analysis remains the same.

[6]In principal, the type distribution can be different across entrepreneurs. Here, for simplicity, we assume they share the same distribution. But, this does not mean the type realizations are the same. For instance, the types of (A, B) can be $(0, 0)$ with probability λ^2, be $(0, 1)$ with probability $\lambda(1 - \lambda)$, be $(1, 0)$ with probability $\lambda(1 - \lambda)$, and be $(1, 1)$ with probability $(1 - \lambda)^2$.

If entrepreneur $e \in \{A, B\}$ is product-driven, then entrepreneur e has an ideal product location. In particular, product-driven entrepreneur A has an ideal location $d_A = -d < 0$, and product-driven entrepreneur B has an ideal location $d_B = d > 0$.[7] Some entrepreneurs formed their location preferences when they were superusers (e.g., Pebble time), and some entrepreneurs formed their location preferences from their family inheritance (e.g., LIV). Their ideal locations can often be found in the background stories of the projects.

If an entrepreneur creates a crowdfunding project on the platform, then that entrepreneur posts a product location, a funding goal, and product price on the campaign website. Product location x_e is the actual product location chosen and posted on the project website by the entrepreneur e. In particular, we let $x_A \in [-1, 0]$ and $x_B \in [0, 1]$. In many crowdfunding platforms such as Kickstarter, entrepreneurs set funding goals—the amount of money they need to produce and deliver their final products—when they create projects. The entrepreneurs will receive the raised funding only if their funding goals are reached by the end of the campaign. We write $G_e > 0$ for the funding goal of entrepreneur e's project. We assume entrepreneurs are price-takers, i.e., each entrepreneur posts the market price $p > 0$ on the campaign website. The reason for the price-taking assumption is twofold. First, we focus on a competitive market where entrepreneurs on a crowdfunding platform do not have the market power to set the price. Second, many reward-based crowdfunding projects aim to reach out to more backers for future market release or financing opportunities such as venture capital (see Roma et al. (2018)), and so entrepreneurs focus on maximizing market share while taking the market price as given.[8]

If a project's funding goal is reached, the entrepreneur pays a fraction $\phi \in (0, 1)$ of the raised funding to the platform and exerts effort to make final products with quality $q \in [0, 1]$

[7]Note that product-driven entrepreneurs A and B's ideal locations are symmetric around zero. We adopt the symmetry assumption for analytical elegance. Assuming symmetric horizontal preferences among competitors in duopolistic market is a common practice in the literature (e.g., Levin et al. (2009) and Janssen and Roy (2010)). Without this assumption, we would lose analytical tractability and the associated insights.

[8]Strategic pricing is also important in crowdfunding campaign, and has been studied in the literature (see Chang (2016),Ellman and Hurkens (2019)). Here, we focus on a different yet important perspective of crowdfunding campaigns—reaching out to backers for future market release or other financing opportunities.

and deliver them to backers. Here, $q_e = 0$ represents the resulted quality if the entrepreneur exerts a minimum level of effort, and $q_e = 1$ represents the resulted quality if the entrepreneur exerts a maximum level of effort. The cost (of effort) to deliver quality q_e for final products is γq_e^2, where $\gamma > 0$ is the marginal development cost. In reality, we can think of this as the cost of adopting new production technology or improving managerial practices to conduct better quality control. For simplicity, we normalize the unit production cost to zero.

We write s_e for entrepreneur e's market share and $\sum_{e \in \{A,B\}} s_e = 1$. Suppose the raised funding of entrepreneur e exceeds the funding goal, i.e., $ps_e \geq G_e$. If entrepreneur e is profit-driven, then the entrepreneur obtains net funding $(1-\phi)ps_e$ from the crowdfunding campaign, and pays a development cost γq_e^2. If entrepreneur e is product-driven, in addition to obtaining $(1-\phi)ps_e$ funding and paying γq_e^2 cost, product-driven entrepreneur gains I utils from creating a project with ideal product location and the highest quality, and incurs a disutility of deviating from the product with ideal location d_e and and the highest quality 1, $(d_e - x_e)^2 + (1 - q_e)^2$. The disutility is increasing in the distance between the entrepreneur's location choice and ideal location measured by $(d_e - x_e)^2$, and the distance between the entrepreneur's quality choice and the highest quality measured by $(1 - q_e)^2$.[9] If the funding goal has not been reached by the end of the campaign, both types of entrepreneurs receive 0 utility. Entrepreneurs' funding goals should cover their costs, that is, $G_e \geq (1-\phi)ps_e - \gamma q_e^2$. Formally, the payoff of type $t \in \{0, 1\}$ entrepreneur $e \in \{A, B\}$ is

$$u_e(x_e, G_e, q_e; d_e, t) = \begin{cases} t\left[I - (d_e - x_e)^2 - (1 - q_e)^2\right] + (1-\phi)ps_e - \gamma q_e^2 & \text{if } ps_e \geq G_e, \\ 0 & \text{if } ps_e < G_e; \end{cases} \tag{1}$$

where $G_e \geq (1-\phi)ps_e - \gamma q_e^2$. If an entrepreneur does not create a project, then the entrepreneur receives utility 0. Without loss of generality, we assume that if an entrepreneur

[9] We measure the disutility as a quadratic distance between actual location/quality choices and ideal location/quality choices to capture entrepreneurs' diminishing marginal return of moving close to the ideal location and highest quality. Our results do not depend on the quadratic form as long as the entrepreneur's disutility increases and concave in the distances.

is indifferent between creating or not creating a project, then the entrepreneur chooses not to create a project.

Platform. The platform's payoff has two parts: current commission revenue and future reputation, which determines the expected future commission. The current commission is a fraction $\phi \in [0, 1]$ of the raised funding by all entrepreneurs, i.e., ϕp. The future reputation depends on the future customer base $\eta(\bar{Q})$ which is an increasing function of the platform's average quality of the projects on the platform. Formally, the platform's payoff is

$$v = \underbrace{\phi p \cdot 1}_{\text{current}} + \underbrace{\phi p \cdot \eta(\bar{Q})}_{\text{future}}$$

where 1 is the current customer base, η is future customer base, $\bar{Q}$ is the average quality of the projects on the platform:

$$\bar{Q} = s_A q_A^* + s_B q_B^*,$$

and $\eta'(\cdot) > 0$.

Timeline. The timeline is as follows.

1. Crowdfunding platform determines the commission rate ϕ.

2. Nature randomly chooses entrepreneurs A and B's types from $\{0, 1\}$ which are privately observed by each of them. An entrepreneur is profit-driven with probability λ and product-driven with probability $1 - \lambda$.

3. Two entrepreneurs simultaneously announce their product locations x_A, x_B and funding goals G_A, G_B.

4. Backers observe the product locations and funding goals, update their beliefs and make investment choices.

5. Entrepreneur $e \in \{A, B\}$ gets funded if funding goal is reached. Then the entrepreneur pays commission to the platform, chooses quality, and makes the product. If the funding goal is not reached, the entrepreneur gets 0.

6. Products are delivered to backers, and quality is realized. All payoffs are realized.

The game between entrepreneurs and backers is a signaling game, with two senders (entrepreneurs) and multiple receivers (backers). We use the solution concept *perfect Bayesian equilibrium*, where entrepreneurs, backers, and the platform maximize their expected payoffs at every history given the beliefs. Beliefs are derived by Bayes' rule whenever possible.

We write $(x_e(t), G_e(t), q_e(t))_{t=0,1}$ for entrepreneur $e \in \{A, B\}$'s pure strategy profile, where $x_e(t)$, $G_e(t)$ and $q_e(t)$ are the equilibrium product location, equilibrium funding goal and equilibrium quality chosen by a type t entrepreneur e, respectively. Since product quality is realized after entrepreneurs get funded, only $x_e(t)$ and $G_e(t)$ affect backers' belief when they make investment decisions. That is, the announced designs and funding goals serve as signals of project quality. We write $\sigma_e(x, G; t)$ for type t entrepreneur e's (mixed) strategy regarding design and funding goal, that is, the probability type t entrepreneur e assigned to each x and G in equilibrium. We define backers' posterior beliefs as follows. Conditional on observing entrepreneur e choosing x and G, backers believe the probability of entrepreneur e being profit-driven ($t = 0$) is

$$\mu_e(x, G) = \frac{\lambda \sigma_e(x, G; 0)}{\lambda \sigma_e(x, G; 0) + (1 - \lambda)\sigma_e(x, G; 1)}$$

4 Equilibrium Analysis

We solve the equilibrium backward by first solving the signaling game between entrepreneurs and backers, and then we solve the platform's optimal commission rate. For the signaling game, by backward induction, we take entrepreneurs' location and funding goal choices as given, and solve for the entrepreneur's equilibrium quality choice.

Lemma 1. *For any entrepreneur $e \in \{A, B\}$, the profit-driven entrepreneur chooses quality $q_e^*(0) = 0$, and the product-driven entrepreneur chooses quality $q_e^*(1) = \frac{1}{1+\gamma}$.*

Proof. See online appendix. ■

By Lemma 1, in equilibrium, we have $q_e^*(0) = 0$ and $q_e^*(1) = \frac{1}{1+\gamma}$ for any entrepreneur. For brevity, henceforth we drop the subscript e of $q_e(t)$'s. That is, any type 0 entrepreneur chooses $q^*(0) = 0$ and any type 1 entrepreneur chooses $q^*(1) = \frac{1}{1+\gamma}$. This lemma implies a simple yet important property of the equilibrium: Product quality is increasing in one's type. As a consequence, ceteris paribus, backers prefer projects from the product-driven entrepreneurs since the quality is expected to be higher.

Next, we turn to the entrepreneurs' equilibrium location. We show that in any equilibrium, profit-driven entrepreneurs choose equilibrium locations weakly closer to median location 0 and earn weakly greater market share than product-driven entrepreneurs. Since profit-driven entrepreneurs are not concerned about the product location, they are less constrained to seek profit, resulting in a (weakly) greater expected market share. In the meantime, product-driven entrepreneurs would choose locations closer to the ideal locations. Lemma 2 formally states this property.

Lemma 2. *For any entrepreneur $e \in \{A, B\}$ with $d_A = -d$ and $d_B = d$, if the entrepreneur of any type creates a project on the platform, the following statements hold in equilibrium.*

(i) A product-driven entrepreneur e chooses product location that is weakly closer to its own ideal location than a profit-driven entrepreneur e, i.e., $|x_e^*(0) - d_e| \geq |x_e^*(1) - d_e|$.

(ii) A profit-driven entrepreneur e expects to earn a weakly greater market share than a product-driven entrepreneur e. That is, $\mathrm{E}_{t_{e'}}[s_e(0)] \geq \mathrm{E}_{t_{e'}}[s_e(1)]$, where e' refers to the opponent entrepreneur of e, that is, $e' \in \{A, B\}$ and $e' \neq e$.

Proof. See online appendix. ■

In general, there are many equilibria in our game, since perfect Bayesian equilibrium allows for arbitrary off-equilibrium-path beliefs. To restrict off-equilibrium-path beliefs in a reasonable way, we characterize equilibrium under the requirement of *Condition D1*, see Banks and Sobel (1987) and Cho and Kreps (1987). The idea is as follows. Consider any $t, t' \in \{0, 1\}$. If type t entrepreneur benefits more from a deviation than type t', then after observing the deviation, backers would think that type t' is less likely to be the deviator. Condition D1 pushes the logic to the limit, so that backers would assign probability zero to type t'.[10]

The rest of this section characterizes the equilibrium under Condition D1. By Lemma 1, backers prefer product-driven entrepreneurs, ceteris paribus. The quality concerns create an incentive for entrepreneurs to separate and mimic: Product-driven entrepreneurs wish to separate from profit-driven entrepreneurs and signal their types to backers, whereas profit-driven entrepreneurs seek to mimic product-driven entrepreneurs and hide their types from backers.

Proposition 1 characterizes entrepreneurs' equilibrium locations and funding goals taking the platform's commission rate ϕ as given. Note that here we focus on the parameter values that $\frac{2\gamma}{p(1+\gamma)^2} \leq 1$. Otherwise, the most a product-driven entrepreneur earns cannot cover its development cost even if the platform charges 0 commission. Then we have a trivial equilibrium wherein product-driven entrepreneurs will not create a project.

Proposition 1. *Define* $\underline{\theta} =: \sqrt{(1-\lambda)(2\gamma+1)}/(1+\gamma)$; $\overline{\theta} =: \sqrt{2\gamma+1}/(1+\gamma)$; $\sigma^* =: (1-\underline{\theta}^2/d^2)/\lambda$; $\underline{s} =: \frac{\gamma}{(1-\phi)p(1+\gamma)^2}$; *and* $\hat{d} =: \min\{d, \frac{1-2\underline{s}+\sqrt{(1-2\underline{s})^2+\lambda^2\overline{\theta}^2}}{\lambda}\}$. *Taking the platform's commission rate* ϕ *as given, an equilibrium exists for the signaling game between the entrepreneurs and backers.*

(i) If $\phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}$, *profit-driven entrepreneur* e *chooses location* $x_e^*(0) = 0$, *and funding goal* $G_e^*(0) = \phi p$; *no product-driven entrepreneur creates a project.*

(ii) If $d \in [0, \underline{\theta}]$ *and* $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$, *there exists a unique pooling equilibrium, wherein both types of entrepreneur* e *chooses ideal location,* $|x_e^*(0)| = |x_e^*(1)| = d$; *and both types of entrepreneur* e *chooses the same funding goal,* $G_e^*(0) = G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$.

[10] In Appendix Appendix B, we discuss in detail how we apply Condition D1 in our setup.

(iii) If $d \in (\underline{\theta}, \overline{\theta})$ *and* $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$*, there exists a unique hybrid equilibrium, wherein product-driven entrepreneur* e *chooses ideal location* $|x_e^*(1)| = d$*, and funding goal* $G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$*; profit-driven entrepreneur* e *choose the profile of location and funding goal* $(|x_e^*(0)|, G_e^*(0)) = \left(0, \frac{\phi p}{2}\right)$ *with probability* σ^**, and choose the profile* $(|x_e^*(0)|, G_e^*(0)) = \left(d, \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}\right)$ *with probability* $1 - \sigma^*$*.*

(iv) If $d \in [\overline{\theta}, 1]$ *and* $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$*, there exists a separating equilibrium.*[11] *In any separating equilibrium, profit-driven entrepreneur* e *chooses median location* $x_e^*(0) = 0$*, and product-driven entrepreneur chooses*

$$|x_e^*(1)| = x^s(1) \in \arg\max_{x' \in [\overline{\theta}, \hat{d}]} \left\{ -(d - x')^2 - \frac{x'}{4} + \lambda \frac{1 + 2\gamma}{4(1+\gamma)^2 x'} \right\}; \quad (2)$$

profit-driven entrepreneur e *chooses funding goal* $G_e^*(0) = \phi p \left[\frac{1}{2} + \frac{(1-\lambda)x^s(1)}{4} - \frac{\underline{\theta}^2}{4(x^s(1))}\right]$ *and product-driven entrepreneur* e *chooses* $G_e^*(1) = \phi p \left[\frac{1}{2} - \frac{\lambda x^s(1)}{4} + \frac{\lambda \overline{\theta}^2}{4x^s(1)}\right] + \frac{\gamma}{(1+\gamma)^2}$*.*

Proof. See online appendix. ■

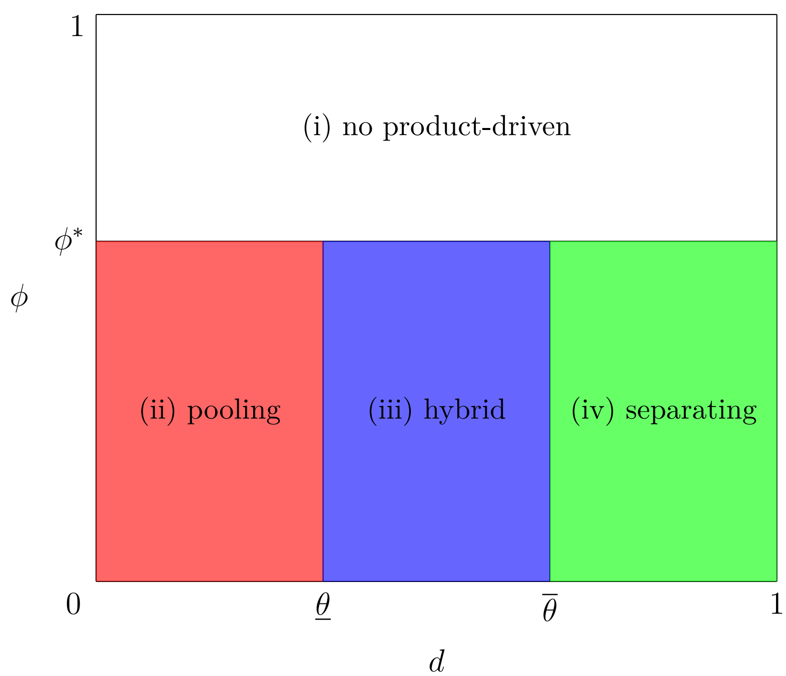
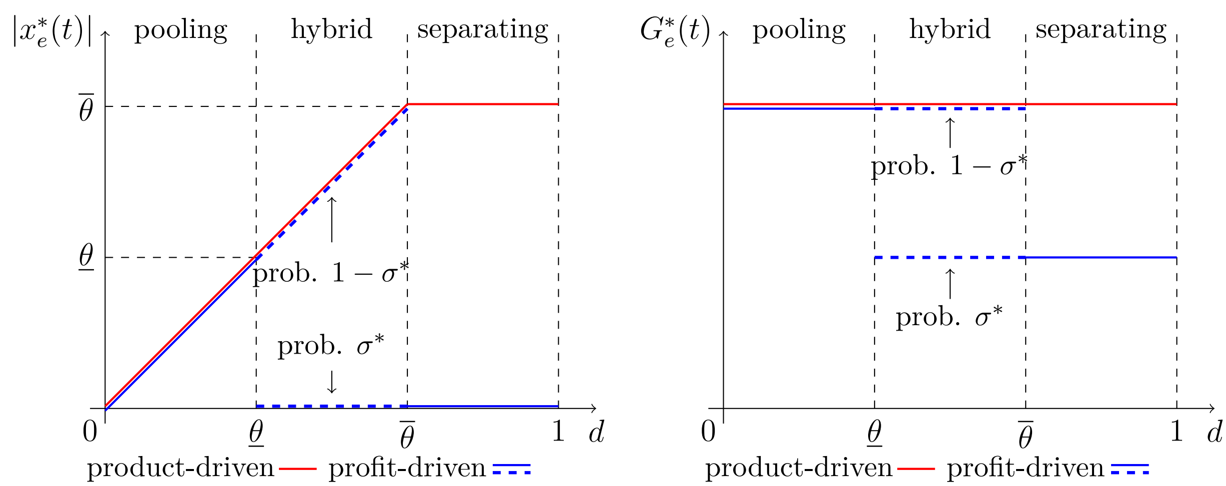


Figure 1: Plot equilibrium forms against d and ϕ, $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$

[11] The equilibrium may not be unique for any commission rate ϕ.

Figure 1 illustrates how equilibrium forms vary across ideal location and commission rate in Proposition 1. In the white area of the figure, the commission rate is sufficiently high ($\phi > \phi^*$) so that product-driven entrepreneurs face costs that are higher than the potential profit anyway. As a result, they would not create any project on the platform. When $\phi \leq \phi^*$, competition among potentially heterogeneous motivated entrepreneurs exists on the platform. Profit-driven entrepreneurs have incentives to mimic product-driven entrepreneurs, whereas product-driven entrepreneurs have incentives to separate from profit-driven entrepreneurs. Their incentives to mimic or separate vary when the value of entrepreneurs' ideal locations change. As a result, we have three forms of equilibrium: pooling equilibrium (red area), hybrid (blue area), or separating equilibrium (green area).



(a) Equilibrium location

(b) Equilibrium funding goal

Figure 2: Plot equilibrium location and funding goal against d for $\phi = 1 - \frac{2\gamma}{p(1+\gamma)^2}$. For $d \in [0, \underline{\theta}]$, $|x_e^*(0)| = |x_e^*(1)| = d$ and $G_e^*(0) = G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$ (pooling equilibrium); for $d \in [\underline{\theta}, \overline{\theta}]$, $|x_e^*(0)| = 0$ and $G_e^*(0) = \frac{\phi p}{2}$ with probability σ^*, $|x_e^*(0)| = d$ and $G_e^*(0) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$ with probability $1-\sigma^*$, $|x_e^*(1)| = d$ and $G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$ (hybrid equilibrium); for $d \in [\overline{\theta}, 1]$, $|x_e^*(0)| = 0 \;\; G_e^*(0) = \frac{\phi p}{2}$, $|x_e^*(1)| = \overline{\theta}$, and $G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$(separating equilibrium).

Now we focus on the case where $\phi \leq \phi^*$ and discuss how entrepreneurs' equilibrium locations and funding goals vary across the ideal location as shown in Figure 2. For illustration purpose, we take commission rate $\phi = \phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$.[12] When the ideal location is close to the median location (i.e., $d \in [0, \underline{\theta}]$), a profit-driven entrepreneur's benefit from mimicking the product-driven entrepreneur outweighs the cost of not appealing to median backers and setting a higher funding goal. In this case, a unique pooling equilibrium exists: both types of entrepreneurs e choose the same location and funding goal.

As the ideal location moves further away from the median location, a profit-driven entrepreneur's cost of not appealing to median backers becomes higher. When $d \in [\underline{\theta}, \overline{\theta}]$, the profit-driven entrepreneur assigns a positive probability to the strategy that not mimicking the product-driven—appealing to the median backer and setting a lower funding goal, and the probability is smaller than one and is increasing as d increases. Thus, in this case, a profit-driven entrepreneur's type is more likely to be revealed compared to the case of $d \in [0, \underline{\theta}]$, but is not revealed with probability one; and the profit-driven entrepreneur's benefit from mimicking the product-driven entrepreneur equals the cost of not appealing to median backers and setting a higher funding goal. A unique hybrid equilibrium exists for $d \in [\underline{\theta}, \overline{\theta}]$. In this case, a product-driven entrepreneur chooses the ideal location and a high funding goal; a profit-driven entrepreneur mimics the product-driven with some probability—choosing the ideal location and a high funding goal, but with some probability reveal its type—choosing the median location and a low funding goal.

When the ideal location moves further such that $d \geq \overline{\theta}$, a profit-driven entrepreneur's benefit from mimicking the product-driven entrepreneur becomes less than the cost of not appealing to median backers and setting a higher funding goal. A profit-driven entrepreneur no longer has incentives to mimic the product-driven entrepreneur and assign probability one to choose the median location and set a lower funding goal. Thus, a separating equilibrium exists for $d \in [\overline{\theta}, 1]$. For $\phi = \phi^*$, the separating equilibrium is unique: a profit-driven entrepreneur chooses the median location and a low funding goal, whereas a product-driven entrepreneur chooses $\overline{\theta}$ and a high funding goal.[13] For any arbitrary commission rate ϕ, the

[12] In fact, we show in Proposition 2 later the commission rate is optimal for the platform.

[13] This is shown later in Proposition 3.

separating equilibrium may not be unique (since the solution of (2) may not be unique).

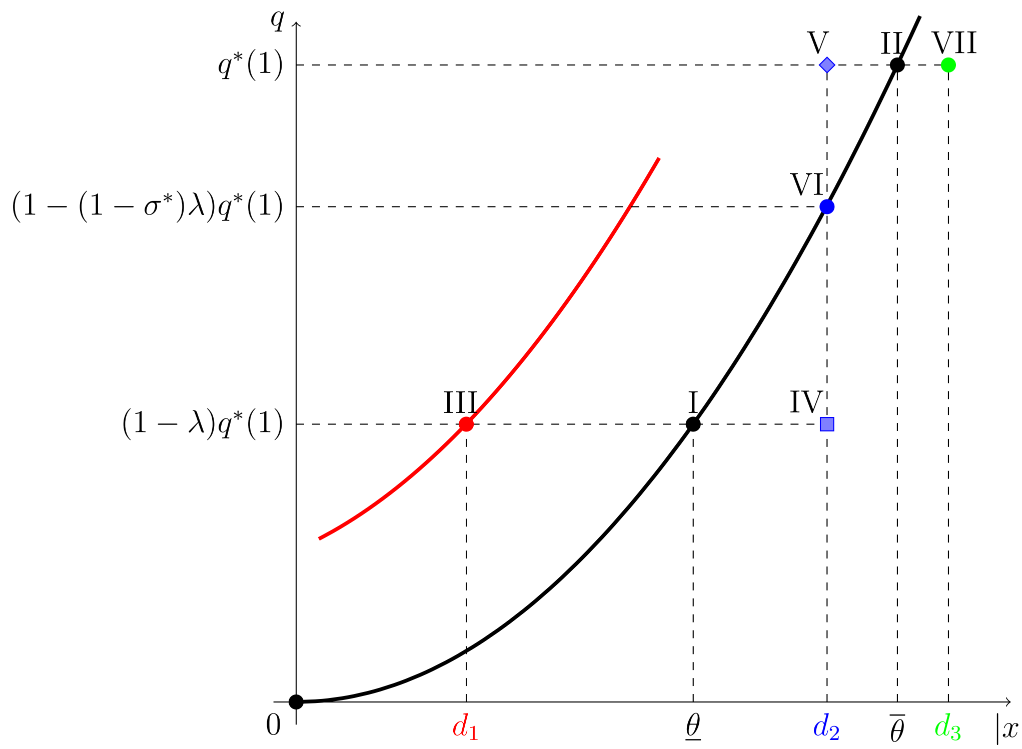


Figure 3: Median backer's indifference curve on product location x and quality q

In what follows, we focus on the case $\phi \leq \phi^*$ and explain why the profit-driven entrepreneur's incentives to mimic and separate change at the cutoffs $\underline{\theta}$ and $\overline{\theta}$ through Figure 3. To better illustrate the intuition, here we only consider the cases where funding goals are reached.[14] Figure 3 depicts the indifference curve of the median backer whose ideal location is 0. The indifference curve goes through the origin $(0, 0)$, point I, $(\underline{\theta}, (1-\lambda)q^*(1))$, and point II, $(\overline{\theta}, q^*(1))$, where $q^*(1) = \frac{1}{1+\gamma}$, and $(1-\lambda)q^*(1)$ is the expected quality under backers' prior belief (i.e., the probability of $t = 0$ is λ). This means that the median backer is indifferent among the combination of the median location 0 and low quality 0, the combination of location $\underline{\theta}$ (or -$\underline{\theta}$) and expected quality given prior $(1-\lambda)q^*(1)$, and the combination of location $\overline{\theta}$ (or -$\overline{\theta}$) and high quality $q^*(1)$.

In any pooling equilibrium, both types of entrepreneur A choose the ideal location $-d$

[14]We discuss conditions that whether funding goals are reached or not in the proof of Proposition 1.

and the same funding goal, and both types entrepreneur B choose the ideal location d and the same funding goal. If the equilibrium location is not the ideal location, a product-driven entrepreneur always has an incentive to choose a location ε closer to the ideal location to separate from the profit-driven one. It will reduce the disutility of deviating from the ideal location. Since backers cannot tell entrepreneurs' types in pooling equilibrium, the median backer (whose ideal location is 0) is indifferent between investing in entrepreneur A or B. All the backers whose ideal location is on the right (respectively, left) of the median location 0 strictly prefer entrepreneur B's project (respectively, entrepreneur A's project). As a result, entrepreneur A and B each gets half of the market.

We now fix A's strategy and consider B's strategy. A profit-driven entrepreneur B will not deviate from the pooling equilibrium (i.e., mimicking the product-driven) if and only if at the most profitable deviation, it still cannot attract the median backer, and so cannot earn more than half of the market share. In fact, the most profitable deviation for the profit-driven one is the median location 0 and a low funding goal. As shown by Figure 3, for ideal location $d_1 \in [0, \underline{\theta}]$, a backer would expect the quality a project with location d_1 and a high funding goal is $(1-\lambda)q^*(1)$ (point III). Because in a pooling equilibrium, the profit-driven entrepreneur mimics the product-driven—choosing ideal location d_1 and a high funding goal—a backer would infer an entrepreneur's type based on the prior—the probability of an entrepreneur being profit-driven is λ. If the profit-driven entrepreneur deviates to median location 0 and a low funding goal, a backer will infer that the entrepreneur is profit-driven. The project offered now would be the origin $(0, 0)$. Apparently, point III is more attractive to the median backer than the origin, since point III lies northwest to the black indifference curve that crosses the origin. Thus deviating to the median location 0 and a low funding goal is not a profitable deviation for any $d \in [0, \underline{\theta}]$.

When $d > \underline{\theta}$, deviating to the median location and a low funding goal becomes more attractive for a profit-driven entrepreneur. As shown in Figure 3, for ideal location $d_2 \in (\underline{\theta}, \overline{\theta})$, if mimicking the product-driven, the profit-driven entrepreneur's project would be at point IV $(d_2, (1-\lambda)q^*(1))$, which is to the southeast of the black indifference curve. Thus, deviating is profitable—profit-driven entrepreneur would assign positive probability to the median location to attract median backer and gain more market share. As a result, a pooling equilibrium does not exist when $d > \underline{\theta}$. But assigning probability one to the median location would fully reveal profit-driven entrepreneur's type. In that case, for ideal location d_2, the profit-driven entrepreneur's project is at the origin $(0,0)$ and the product-driven entrepreneur's project is at the point V, (d_2, q_1). Since point V is to the northeast of the black indifference curve cross the origin, the product-driven entrepreneur's project is more attractive to the median backer. So the product-driven earns a higher market share. It contradicts with Lemma 2 that profit-driven entrepreneur earns weakly higher market share. Otherwise, the profit-driven can always mimic the product-driven and earn the same market share. As a result, a separating equilibrium does not exist for $d \in (\underline{\theta}, \overline{\theta})$.

In fact, for ideal location $d_2 \in (\underline{\theta}, \overline{\theta})$, a profit-driven entrepreneur would assign σ^* to the median location and assign $1-\sigma^*$ to mimic the product-driven—choosing ideal location d_2 and a high funding goal. Thus, when the profit-driven does not mimic the product-driven, the project is at $(0,0)$; and if the profit-driven does mimic the product-driven, the project is at the point VI, $(d_2, (1-(1-\sigma^*)\lambda)q^*(1)$. When choosing such strategy, according to Bayes' rule, backers will believe that the probability of a product-driven entrepreneur creating a project with location d_2 and a high funding goal is $(1-(1-\sigma^*)\lambda)q^*(1)$. The probability of a product-driven entrepreneur creating a project with location 0 and a low funding goal is 0. In this case, since the origin and point VI lie on the same indifference curve, the median backer is indifferent between the projects of the profit-driven entrepreneur and the product-driven one, and the profit-driven one is indifferent between mimicking and not mimicking. As a result, a hybrid equilibrium exists for $d \in (\underline{\theta}, \overline{\theta})$.

Finally, when $d \geq \overline{\theta}$, profit-driven entrepreneurs would assign probability one to choose the median location 0 and a low funding goal. As shown in Figure 3, suppose the profit-driven entrepreneur mimics the product-driven entrepreneur with positive probability and chooses location d_3. Even if backers believe an entrepreneur who offers a project with location d_3 and a high funding goal to be a product-driven with probability one, mimicking the product-driven to choose the location at the point VII, (d_3, q_1^*), and a high funding goal is less attractive to median backer than a project at the point $(0,0)$ with a low funding goal. As a result, the product-driven entrepreneur has no incentive to mimic the product-driven one, and a separating equilibrium exists for $d \geq \overline{\theta}$.

4.1 Platform's Optimal Commission Rate

Platform's commission rate affects the equilibrium outcome of the signaling game between entrepreneurs and backers. Proposition 1 suggests: as the commission rate increases, the funding goals of all entrepreneurs increase. A very high commission rate would prevent product-driven entrepreneurs from creating projects on the platform (part (i) of Proposition 1). As a result, only the profit-driven entrepreneur creates projects on the platform. In this case, the profit-driven entrepreneur chooses a higher funding goal yet the same location choice as the commission rate increases.

Now we turn to the case where the commission is not high enough to exclude product-driven entrepreneurs. When ideal location $d < \overline{\theta}$ (part (ii) and (iii) of Proposition 1), as commission rate increases, both type entrepreneurs choose higher funding goals yet the same product location. But when ideal location $d \geq \overline{\theta}$ (part (iv) of Proposition 1), as commission rate increases, a product-driven entrepreneur choose a location closer to the median backer and a higher funding goal. A profit-driven entrepreneur chooses the same location choice but a higher funding goal. With a higher funding goal, a product-driven entrepreneur chooses a location closer to the median backer to earn a higher market share to reach the higher funding goals.

Recall that platform utility is comprised of current commission revenue and future reputation, which is determined by the platform's average quality. In fact, as product-driven entrepreneurs earn higher market share, the platform's average quality becomes higher. The average quality for any value of ϕ, given the equilibrium strategies of entrepreneurs and backers, can be expressed as follows:

$$\bar{Q} = \begin{cases} 0 & \text{if } \phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}, \\ \bar{Q}^p & \text{if } \phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2} \text{ and } d \leq \underline{\theta}, \\ \bar{Q}^s & \text{if } \phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2} \text{ and } d \geq \overline{\theta}, \\ \bar{Q}^h & \text{if } \phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2} \text{ and } d \in (\underline{\theta}, \overline{\theta}), \end{cases}$$

where

$$\begin{aligned} \bar{Q}^p &= (1-\lambda)\frac{1}{1+\gamma}, \\ \bar{Q}^s &= \left[(1-\lambda^2) - \lambda(1-\lambda)\left(x^s(1) - \frac{2\gamma+1}{x^s(1)(1+\gamma)^2}\right)\right]\frac{1}{1+\gamma}, \\ \bar{Q}^h &= \left[(1-\lambda)(1-\sigma^*\lambda) - \sigma^*\lambda(1-\lambda)\left(d - \frac{2\gamma+1}{d(1+\gamma)^2}\right)\right]\frac{1}{1+\gamma}, \\ &\text{with } \sigma^* = (1-\underline{\theta}^2/d^2)/\lambda. \end{aligned}$$

The platform's commission rate can affect entrepreneurs' choices and affect the platform's average quality further. Therefore, the platform faces a trade-off between current commission revenue vs. future reputation. We solve optimal commission rate ϕ for the platform in Proposition 2. Define $\bar{\eta} =: \left(\left(1+\lambda-\lambda x^s(1) - \frac{\lambda\bar{\theta}^2}{x^s(1)}\right)\frac{(1-\lambda)\gamma}{(1-\phi)p(1+\gamma)^2}\right) - \frac{2\gamma}{p(1+\gamma)^2}$.

Proposition 2. *In any equilibrium, if $\eta(0) < \bar{\eta}$, it is optimal for the platform to choose $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$.*

Proof. See online appendix. ■

The condition $\eta(0) < \bar{\eta}$ ensures that the platform cares sufficiently about future reputation. In reality, crowdfunding platforms do care a lot about future reputation, and they may sacrifice current profit through, e.g., subsidizing entrepreneurs and backers for future customer base and profit. As the platform cares about future reputation, it would want to attract product-driven entrepreneurs. As a result, the commission rate cannot be too high.

As shown in Figure 4, if the commission rate is too high, the platform would end up without any product-driven entrepreneurs and result in lower expected utility. On the other hand, the optimal commission rate would not be very low. When $d < \overline{\theta}$, the platform's expected utility is linearly increasing in the commission rate. It is because a rise in commission rate would not change the location choices of entrepreneurs in this case. However, when $d \geq \overline{\theta}$, a rise in commission rate forces the product-driven entrepreneur to choose a more moderate location to achieve a higher market share. It increases the platform's expected utility non-linearly. Therefore, as long as the platform sufficiently cares about future profit, the optimal commission rate is the highest commission rate that a platform can charge to keep the product-driven entrepreneurs on the platform, i.e., $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$.

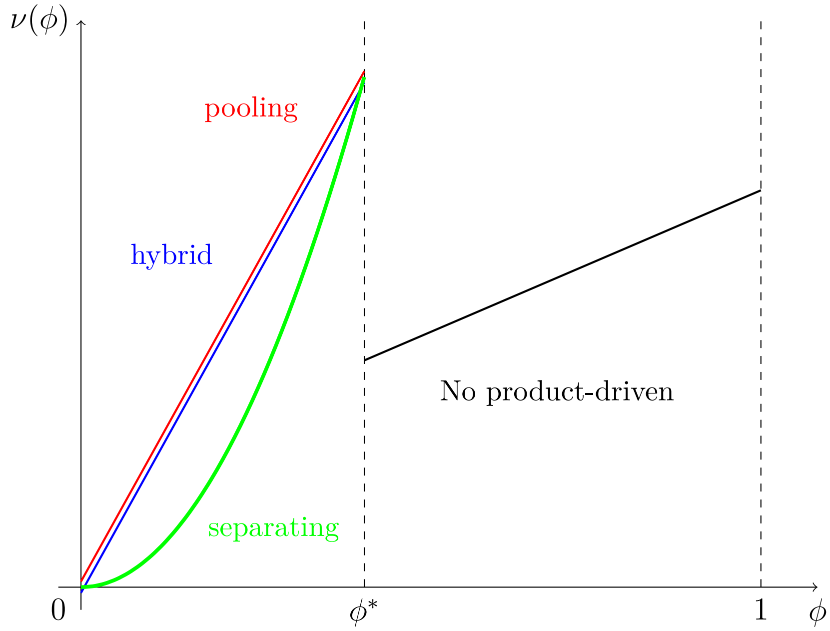


Figure 4: Plot platform's expected utility against commission rate

Given the optimal commission rate, we can specify the equilibrium outcomes for the signaling game between the entrepreneurs and backers.

Proposition 3. *If $\eta(0) < \bar{\eta}$, there exists a unique equilibrium of the signaling game between the entrepreneurs and backers.*

(i) If $d \in [0, \underline{\theta}]$, there exists a unique pooling equilibrium, wherein both types of entrepreneur e chooses ideal location, $|x_e^*(0)| = |x_e^*(1)| = d$; and both types of entrepreneur e chooses the same funding goal, $G_e^*(0) = G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$.

(ii) If $d \in (\underline{\theta}, \overline{\theta})$, there exists a unique hybrid equilibrium, wherein product-driven entrepreneur e chooses ideal location $|x_e^*(1)| = d$, and funding goal $G_e^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$; profit-driven entrepreneur e choose the profile of location and funding goal $(|x_e^*(0)|, G_e^*(0)) = \left(0, \frac{\phi p}{2}\right)$ with probability σ^*, and choose the profile $(|x_e^*(0)|, G_e^*(0)) = \left(d, \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}\right)$ with probability $1 - \sigma^*$.

(iii) If $d \in [\overline{\theta}, 1]$, there exists a unique separating equilibrium, wherein profit-driven entrepreneur e chooses median location $x_e^*(0) = 0$ and funding goal $G^*(0) = \frac{1}{2}\phi^* p$, product-driven entrepreneur e chooses location $|x_e^*(1)| = \overline{\theta}$ and funding goal $G^*(1) = \frac{1}{2}\phi^* p + \frac{\gamma}{(1+\gamma)^2}$.

Under the optimal commission rate, a unique equilibrium of the signaling game exists. In equilibrium, product-driven entrepreneurs always create projects on the platform. When $d \in [0, \underline{\theta}]$, there exists a unique pooling equilibrium, wherein both type entrepreneur e choose ideal location and a high funding goal. When $d \in (\underline{\theta}, \overline{\theta})$, there exists a unique hybrid equilibrium, wherein a product-driven entrepreneur chooses the ideal location and a high funding goal. A profit-driven entrepreneur mimics the product-driven with some probability—choosing the ideal location and a high funding goal, but with some probability reveals its type—choosing the median location and a low funding goal. When $d_1 \in [\overline{\theta}, 1]$, there exists a unique separating equilibrium, wherein a product-driven entrepreneur chooses location $\overline{\theta}$ and a high funding goal. In contrast, a profit-driven entrepreneur chooses the median location and a low funding goal.[15] In this case, the optimal commission rate makes the product-driven entrepreneur choose the location closer to the median backer to achieve

[15] By contrast, in Proposition 1, we can only show the equilibrium choice is in the region $[\overline{\theta}, d]$ yet not establish the uniqueness.

a higher market share. As a result, the optimal commission rate effectively limits product-driven entrepreneurs' disadvantage in the competition.

5 Concluding Remarks

Our paper analyzes the incentives of entrepreneurs with heterogeneous motivation (product- vs. profit-driven) on a crowdfunding platform. We propose a mechanism for entrepreneurs to use product locations and funding goals to signal their motivations. To that end, we formulate a spatial competition model wherein heterogeneously motivated entrepreneurs compete for funding on a crowdfunding platform, and the platform sets an optimal commission rate to maximize its current revenue and future reputation. We solve for the platform's optimal commission rate, under which—depending on the distance between the entrepreneur's ideal location and the median backer's ideal location—a unique pooling, separating, or hybrid equilibrium exists. We show that it is optimal for the platform to charge a moderate commission fee.

Contributions. First of all, we are the first paper to consider the role of product-driven entrepreneurs in the crowdfunding market. Existing studies assume that entrepreneurs in the crowdfunding market, or, more broadly, in the entrepreneurial financial market, are profit-driven. However, as documented by Younkin and Kashkooli (2016), one advantage of the crowdfunding market is that it allows heterogeneously motivated entrepreneurs, including the product-driven ones, to access funding from crowds. Our study shows that the mechanism of crowdfunding helps a broader range of entrepreneurs appeal directly to a general audience and access resources successfully.

Second, our model captures the idea that niche offerings and high funding goals can be leveraged by entrepreneurs when they signal their motivation. This is particularly relevant for the crowdfunding market, wherein all entrepreneurs post their product locations on a crowdfunding platform. Existing studies focus on entrepreneurs' use of dissipative advertising to signal exogenously determining product quality. In contrast, ours proposes a novel mechanism in the crowdfunding context that entrepreneurs endogenously choose quality according to their heterogeneous motivations and use product locations and funding goals to signal their motivation. We show how and when product-driven entrepreneurs separate from profit-driven entrepreneurs through the proposed signaling mechanism. Our results shed light on crowdfunding campaign design.

Finally, we are the first paper to consider the platform's commission policy design. We explicitly model the platform's trade-off between current profit and future reputation. We discuss how the platform's choice of commission rate affects the strategic interaction between heterogeneously motivated entrepreneurs and backers. We find that the optimal commission rate is the highest commission rate that a platform can charge to keep the product-driven entrepreneurs on the crowdfunding platform. The optimal commission rate forces the product-driven entrepreneur to earn the highest possible market share, thus limiting product-driven entrepreneurs' disadvantage in the competition. This result implies that the mechanism of crowdfunding further reduces the barrier of financing for product-driven entrepreneurs.

Limitations and future research. First of all, our paper focuses on competitive product market and price-taking entrepreneurs. We acknowledge the importance of strategic pricing, yet we believe our model can be the building block for further research to study strategic pricing in a competitive crowdfunding market.

Second, to simplify the study, we assume that the competition is only between the two firms, not capturing the whole reality. Nevertheless, we believe that duopolistic competition is an important step and can help us understand the effect of competition on entrepreneurs and crowdfunding platforms. It may be worthwhile, in future research, to study the equilibrium effect when three or more firms enter the market by applying a circular spatial competition model.[16]

Third, we assume that each entrepreneur is a binary type—either profit-driven or product-

[16] In general, equilibrium existence is problematic for a linear spatial model with three or more players.

driven. We use the two types to capture the heterogeneity of entrepreneurs' motivations, while in reality, there may be many more or even continuous types. It may be worthwhile, in future research, to study the case with a more general type structure.

Fourth, we assume that the ideal locations of the two entrepreneurs are symmetric, which may not be true in reality. However, the problem with asymmetric ideal locations, in general, is hard to solve analytically. We assume symmetry to render the computationally hard problem solvable by reducing the dimensionality to deliver the insights. In fact, the symmetry assumption has been widely used in the literature to obtain an analytically tractable solution (see, e.g.,Levin et al. (2009) and Janssen and Roy (2010)). Though the symmetry assumption is not perfect, the fundamental insights generated from the symmetric environment carry over to a more complicated reality. Whether the results hold true more generally in the asymmetric environment is worth exploring with more advanced tools in the future.

Finally, our model generates several testable predictions that potentially shed light on future empirical research. For instance, we can test the positive relationship between the platform's commission rates and project funding goals, the positive relationship between project funding goals, and feedback on project quality in the future.

References

Agrawal, A., Catalini, C., and Goldfarb, A. 2015. "Crowdfunding: Geography, social networks, and the timing of investment decisions," *Journal of Economics & Management Strategy* (24:2), pp. 253–274.

Anderson Jr, E. G., Parker, G. G., and Tan, B. 2013. "Platform performance investment in the presence of network externalities," *Information Systems Research* (25:1), pp. 152–172.

Bagwell, K. 2007. "The economic analysis of advertising," *Handbook of industrial organization* (3), pp. 1701–1844.

Banks, J. S., and Sobel, J. 1987. "Equilibrium selection in signaling games," *Econometrica: Journal of the Econometric Society* pp. 647–661.

Bontems, P., Meunier, V., and Universitet, K. 2005. *Advertising and price signaling of quality in a duopoly with endogenous locations*, Citeseer.

Burtch, G., Ghose, A., and Wattal, S. 2016. "Secret admirers: An empirical examination of information hiding and contribution dynamics in online crowdfunding," *Information Systems Research* (27:3), pp. 478–496.

Chang, J.-W. 2016. "The economics of crowdfunding," *American Economic Journal: Microeconomics* (12:2), p. 2020.

Chemla, G., and Tinn, K. 2019. "Learning through crowdfunding," *Management Science* (Articlues in Advance), pp. 1–19.

Cho, I.-K., and Kreps, D. M. 1987. "Signaling Games and Stable Equilibria," *The Quarterly Journal of Economics* (CII:2).

Choudhary, V., Xin, M., and Zhang, Z. 2018. "Sequential IT Investment: Can the Risk of IT Implementation Failure Be Your Friend?" *Information Systems Research, Forthcoming* .

Ellman, M., and Hurkens, S. 2019. "Optimal crowdfunding design," *Journal of Economic Theory* (184), p. 104,939.

Ho, Y.-C., Ho, Y.-J., and Tan, Y. 2017. "Online Cash-back Shopping: Implications for Consumers and e-Businesses," *Information Systems Research* (28:2), pp. 250–264.

Hotz, V. J., and Xiao, M. 2013. "Strategic information disclosure: The case of multiattribute products with heterogeneous consumers," *Economic Inquiry* (51:1), pp. 865–881.

Hu, M., Li, X., and Shi, M. 2015. "Product and pricing decisions in crowdfunding," *Marketing Science* (34:3), pp. 331–345.

Janssen, M. C., and Roy, S. 2010. “Signaling quality through prices in an oligopoly,” *Games and Economic Behavior* (68:1), pp. 192–207.

Janssen, M. C., and Teteryatnikova, M. 2016. “Horizontal product differentiation: Disclosure and competition,” *The Journal of Industrial Economics* (64:4), pp. 589–620.

Kerr, S. P., Kerr, W. R., and Xu, T. 2018. “Personality traits of entrepreneurs: A review of recent literature,” *Foundations and Trends® in Entrepreneurship* (14:3), pp. 279–356.

Kihlstrom, R. E., and Riordan, M. H. 1984. “Advertising as a Signal,” *journal of Political Economy* (92:3), pp. 427–450.

Kim, K., Park, J., Pan, Y., Zhang, K., and Zhang, X. 2022. “Risk disclosure in crowdfunding,” *Information Systems Research* .

Levin, D., Peck, J., and Ye, L. 2009. “Quality disclosure and competition,” *The Journal of Industrial Economics* (57:1), pp. 167–196.

Milgrom, P., and Roberts, J. 1986. “Price and advertising signals of product quality,” *Journal of political economy* (94:4), pp. 796–821.

Mollick, E. 2014. “The dynamics of crowdfunding: An exploratory study,” *Journal of business venturing* (29:1), pp. 1–16.

Pu, J., Nian, T., Qiu, L., and Cheng, H. K. 2017. “Manipulation for Competition: Agency Pricing in the Presence of Quality Misrepresentation,” *Available at SSRN 2998319* .

Roma, P., Gal-Or, E., and Chen, R. R. 2018. “Reward-Based Crowdfunding Campaigns: Informational Value and Access to Venture Capital,” *Information Systems Research* .

Rose-Ackerman, S. 1996. “Altruism, nonprofits, and economic theory,” *Journal of economic literature* (34:2), pp. 701–728.

Schwienbacher, A., and Larralde, B. 2010. "Crowdfunding of small entrepreneurial ventures," *Handbook of entrepreneurial finance, Oxford University Press, Forthcoming* .

Strausz, R. 2017. "A theory of crowdfunding: A mechanism design approach with demand uncertainty and moral hazard," *American Economic Review* (107:6), pp. 1430–76.

Vettas, N. 1999. "Location as a signal of quality," *London: Centre for Economic Policy Research* (2165).

Yang, L., Wang, Z., and Hahn, J. 2020. "Scarcity strategy in crowdfunding: An empirical exploration of reward limits," *Information Systems Research* (31:4), pp. 1107–1131.

Younkin, P., and Kashkooli, K. 2016. "What problems does crowdfunding solve?" *California Management Review* (58:2), pp. 20–43.

Appendix A Proofs

Proof of Lemma 1. Entrepreneur $e \in \{A, B\}$ makes quality choices after getting funded, that is, the location choices and funding goals are already made. Therefore, by backward induction, after getting funded, given platform commission rate, equilibrium locations, funding goals and backers' investment decisions, type $t \in \{0, 1\}$ entrepreneur e solves the following problem

$$\max_{q_e(t)} I - t\left[(d - x_e^*(t))^2 + (1 - q_e(t))^2\right] + (1 - \phi)ps_e^* - \gamma q_e(t)^2$$

Solving the first order condition with respect to $q_e(t)$ yields

$$q_e^*(t) = \frac{t}{t + \gamma}$$

Plugging in $t = 0, 1$ yields $q_e^*(0) = 0$ and $q_e^*(1) = \frac{1}{1+\gamma}$, respectively. This holds for all e, so henceforth, we can drop the subscript e, and write $q^*(0) = 0$ and $q^*(1) = \frac{1}{1+\gamma}$. ■

Proof of Lemma 2. We only show the statements for entrepreneur B for brevity, and by the same logic, the results for A follows.

Fix an equilibrium strategy profile $(x_A^*(t), x_B^*(t), G_A^*(t), G_B^*(t), q_A^*(t), q_B^*(t))_{t=0,1}$. By Lemma 1, $q_A^*(0) = q_B^*(0) = q^*(0)$ and $q_A^*(1) = q_B^*(1) = q^*(1)$. Given entrepreneur B's type $t \in \{0,1\}$ and entrepreneur A's type $t' \in \{0,1\}$, we write $s_B^*(x_B^*(t), G_B^*(t), q^*(t)) = s_B^*(t)$. Then, entrepreneur B's expected utility (over his belief about entrepreneur A's type) is

$$\begin{aligned}
&\mathrm{E}_{t'}[u_B(x_B^*(t), G_B^*(t), q_B^*(t))] = \\
&\qquad\qquad I - t\left[(d - x_B^*(t))^2 + (1 - q_B^*(t))^2\right] + \mathrm{E}_{t'}\left[(1-\phi)ps_B^*(t)\right] - \gamma q_B^*(t)^2,
\end{aligned}$$

if he creates a project; otherwise entrepreneur B gets a utility 0.

In any equilibrium, each type must be incentive compatible, i.e.,

$$\begin{aligned}
\mathrm{E}_{t'}[u_B(x_B^*(0), G_B^*(0), q_B^*(0)] &\geq \mathrm{E}_{t'}[u_B(x_B^*(1), G_B^*(1), q_B^*(0))], \\
\mathrm{E}_{t'}[u_B(x_B^*(1), G_B^*(1), q_B^*(1))] &\geq \mathrm{E}_{t'}[u_B(x_B^*(0), G_B^*(0), q_B^*(1))],
\end{aligned}$$

or equivalently,

$$\begin{aligned}
&\max\{I + (1-\phi)p\mathrm{E}_{t'}\left[s_B^*(0)\right] - \gamma q^*(0)^2, 0\} \geq \max\{I + (1-\phi)p\mathrm{E}_{t'}\left[s_B^*(1)\right] - \gamma q^*(0)^2, 0\}; \\
&\max\{I - \left[(d - x_B^*(1))^2 + (1 - q^*(1))^2\right] + \mathrm{E}_{t'}\left[(1-\phi)ps_B^*(1)\right] - \gamma q^*(1)^2, 0\} \geq \\
&\quad \max\{I - \left[(d - x_B^*(0))^2 + (1 - q^*(1))^2\right] + \mathrm{E}_{t'}\left[(1-\phi)ps_B^*(0)\right] - \gamma q^*(1)^2, 0\}.
\end{aligned}$$

If each type creates a project on the platform, then the expected utility of that entrepreneur must be great or equal than 0. In that case, we have

$$
\begin{aligned}
&I + (1-\phi)p\mathrm{E}_{t'}\left[s_B^*(0)\right] - \gamma q^*(0)^2 \geq I + (1-\phi)p\mathrm{E}_{t'}\left[s_B^*(1)\right] - \gamma q^*(0)^2;\\
&I - \left[(d - x_B^*(1))^2 + (1-q^*(1))^2\right] + \mathrm{E}_{t'}\left[(1-\phi)ps_B^*(1)\right] - \gamma q^*(1)^2 \geq \\
&\quad I - \left[(d - x_B^*(0))^2 + (1-q^*(1))^2\right] + \mathrm{E}_{t'}\left[(1-\phi)ps_B^*(0)\right] - \gamma q^*(1)^2.
\end{aligned}
$$

or equivalently

$$
0 \leq (1-\phi)\left\{\mathrm{E}_{t'}\left[ps_B^*(0)\right] - \mathrm{E}_{t'}\left[ps_B^*(1)\right]\right\} \leq \left[(d - x_B^*(0))^2 - (d - x_B^*(1))^2\right]. \tag{3}
$$

This further implies

$$
\mathrm{E}_{t'}\left[s_B^*(0)\right] \geq \mathrm{E}_{t'}\left[s_B^*(1)\right] \text{ and } |x_B^*(0) - d| \geq |x_B^*(1) - d|.
$$

■

Lemma 3 describes the market share functions given realized locations and funding goals. This lemma is useful for proofs of Propositions 1.

Lemma 3. *Consider the projects of entrepreneur A, B with realized locations $\hat{\boldsymbol{x}} = (\hat{x}_A, \hat{x}_B)$, funding goal $\hat{\boldsymbol{G}} = (\hat{G}_A, \hat{G}_B)$ and optimal quality $\boldsymbol{q}^* = (q^*(0), q^*(1))$. Suppose both entrepreneurs have reached their funding goals. Then the market share of entrepreneur B is*

$$
s_B = \frac{1}{2} - \frac{\hat{x}_A + \hat{x}_B}{4} - \frac{M_A - M_B}{4\left(\hat{x}_A - \hat{x}_B\right)}.
$$

where $M_A = \mu_A(\hat{x}_A, \hat{G}_A) + (1 - \mu_A(\hat{x}_A, \hat{G}_A))(1 - q^*(1))^2$, and $M_B = \mu_B(\hat{x}_B, \hat{G}_B) + (1 - \mu_B(\hat{x}_B, \hat{G}_B))(1 - q^*(1))^2$. It is decreasing in μ_B and increasing in μ_A. Since $s_A = 1 - s_B$, s_A is decreasing in μ_A and increasing in μ_B.

Proof of Lemma 3. Given realized locations $\hat{\boldsymbol{x}} = (\hat{x}_A, \hat{x}_B)$, funding goal $\hat{\boldsymbol{G}} = (\hat{G}_A, \hat{G}_B)$, we pin down the backer $\hat{x}_A \leq \hat{c} \leq \hat{x}_B$ who is indifferent between investing in A and B:

$$-(\hat{c} - \hat{x}_A)^2 - M_A = -(\hat{c} - \hat{x}_B)^2 - M_B.$$

Rearranging, we have

$$\hat{c} = \frac{\hat{x}_A + \hat{x}_B}{2} - \frac{M_A - M_B}{2(\hat{x}_B - \hat{x}_A)}.$$

Then the market share of entrepreneur B is

$$s_B = \frac{1-\hat{c}}{2} = \frac{1}{2} - \frac{\hat{x}_A + \hat{x}_B}{4} + \frac{M_A - M_B}{4(\hat{x}_B - \hat{x}_A)}.$$

Obviously, the market share of entrepreneur B is decreasing in M_B and increasing in M_A. Since $q^*(1) < 1$, we have M_e is increasing in $\mu_e(x_e)$ for $e \in \{A, B\}$. Therefore, s_B is decreasing in μ_B and increasing in μ_A. ■

In what follows, we show Proposition 1. We first show part (ii) and (iv), then show part (iii), and finally part (i) immediately follows from part (i)-(iii).

Proof of Proposition 1 Part (ii). We show the result of pooling equilibrium in two steps. In the first step, we show in any pooling equilibrium $-x_A(t) = x_B(t) = d$, for $t \in \{0, 1\}$. In the second step, we show the condition for the existence and uniqueness of the pooling equilibrium.

By definition, in any pooling equilibrium both type entrepreneur $e \in \{A, B\}$ choose same strategy. In any pooling equilibrium, we write $G_e^* = G_e^*(0) = G_e^*(1)$ for the funding goal of any type t entrepreneur e, and $x_e^* = x_B^*(0) = x_B^*(1)$ be the product location of any type t entrepreneur e in a pooling equilibrium.

Step 1: First we show a pooling equilibrium exists only if $|x_e^*| = d$. Toward contradiction, suppose there is a pooling equilibrium wherein for some e, $|x_e^*| = x' \neq d$. Next we fix the strategy of entrepreneur e' and show a profitable deviation exists for type 1 entrepreneur e.

Consider a deviation for type 1 entrepreneur e with location x'' , where $(d-x'')^2 = (d-x')^2-\varepsilon$ and $\varepsilon \to 0$. Then

$$\begin{aligned}
&\mathrm{E}_{t'}[u_e(x'', G_e^*, q^*(1)] - \mathrm{E}_{t'}[u_e(x', G_e^*, q^*(1)] \\
&= -t[(d-x^*)^2 - (d-x')^2] + p(\mathrm{E}_{t'}[s_e(x^{''}, G_e^*, q^*(1))] - \mathrm{E}_{t'}[s_e(x^{'}, G_e^*, q^*(1))]) \\
&= -t\varepsilon + p(\mathrm{E}_{t'}[s_e(x^{''}, G_e^*, q^*(1))] - \mathrm{E}_{t'}[s_e(x^{'}, G_e^*, q^*(1))])
\end{aligned}$$

The deviation is profitable if $\mathrm{E}_{t'}[s_e(x^{''}, G_e^*, q^*(1))] - \mathrm{E}_{t'}[s_e(x^{'}, G_e^*, q^*(1))] \leq 0$.

The last inequality is established by the following. By Lemma 4, $\mu_e(x') = 0$, and thus $\mu_e(x') < \mu_e(x^{''}) = \lambda$. Therefore, by Lemma 3 we have $\mathrm{E}_{t'}[s_e(x, G_e, q^*(1)]$ is decreasing in μ_e and, in turn, we have $\mathrm{E}_{t'}[s_e(x^{''}, G_e, q^*(1))] - \mathrm{E}_{t'}[s_e(x^{'}, G_e, q^*(1))] \leq 0$.

Step 2: In what follows, we show the equilibrium with $|x_e^*| = d$ for $e \in \{A, B\}$ exists when the conditions in Proposition 1 Part (ii) hold.

In the case where $|x_e^*| = d$ for $e \in \{A, B\}$, the market share for each entrepreneur is $\frac{1}{2}$. For product-driven entrepreneur e to crowdfund a project with non-negative profit, that is, $G_e^* \geq \frac{\phi p}{2} + \gamma q^*(1)^2 = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$. In equilibrium, $G_e^* = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$ for all e. If $G_e^* > \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$, the product-driven entrepreneur can always lower funding goal to $G_e^*(1)$ to increase the chance of reaching funding goal. Therefore, in a pooling equilibrium, type 1 entrepreneur e cannot reach funding goal if and only if $\frac{1}{2} < G_e^*$ or equivalently $\phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}$. In that case, the product-driven entrepreneur would not create a project. As a result, a pooling equilibrium does not exists if $\phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}$. Thus $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$ is a necessary condition for the existence of a pooling equilibrium.

We now suppose $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$ and show there does not exist a profitable deviation for entrepreneur B if $d \leq \underline{\theta}$. Then, in any pooling equilibrium, the expected utility of type t entrepreneur B is

$$I - t\left(1 - q^*(t)\right)^2 + (1-\phi)\frac{p}{2} - \gamma q^*(t)^2, \tag{4}$$

where $q^*(t) = \frac{t}{t+\gamma}$.

Now suppose type t entrepreneur B deviates to $x' \neq d$. By Condition D1, backers would believe the deviator to be profit-driven with probability 1. Then by Lemma 3, the expected market share would be

$$s'_B = \left[\frac{1}{2} + \frac{d-x'}{4} - \frac{(1-\lambda)(1-(1-q^*(1))^2)}{4(d+x')}\right].$$

Thus the expected payoff of type t entrepreneur B is

$$I - t\left[(d-x')^2 + (1-q^*(t))^2\right] + (1-\phi)ps'_B - \gamma q^*(t)^2, \tag{5}$$

where $G'_B(t) = \phi p s'_B + \gamma q^*(t)^2$.

Type t entrepreneur B has no profitable deviation if and only if (4) $\geq$ (5) holds for all t. Given s'_B, the product-driven entrepreneur would create a project if and only if $\phi \leq 1 - \frac{\gamma}{ps'_B(1+\gamma)^2}$. For $\phi \leq 1 - \frac{\gamma}{ps'_B(1+\gamma)^2}$, type t entrepreneur B has no profitable deviation if and only if

$$(5)-(4) = -t(d-x')^2 + p(1-\phi)\left\{\frac{d-x'}{4} - \frac{(1-\lambda)[1-(1-q^*(1))^2]}{4(d+x')}\right\} \leq 0,$$

for any $t = 0, 1$. This holds if and only if

$$\frac{d-x'}{4} - \frac{(1-\lambda)[1-(1-q^*(1))^2]}{4(d+x')} \leq 0$$

for all $x' \in [0,1]$. If $x' > d$, the above holds vacuously. Otherwise, it holds if and only if $d^2 - x'^2 \leq (1-\lambda)[1-(1-q^*(1))^2]$, for all $x' \in [0,1]$. It is equivalent to

$$d \leq \sqrt{(1-\lambda)[1-(1-q^*(1))^2]} = \sqrt{(1-\lambda)(2\gamma+1)}/(1+\gamma) = \underline{\theta}$$

Therefore, we show the unique pooling equilibrium exists if and only if $d \leq \underline{\theta}$ and $\phi \leq$

$1 - \frac{2\gamma}{p(1+\gamma)^2}$. By the same logic, the result for entrepreneur A follows. Then we establish the existence of the pooling equilibrium under the conditions specified in Proposition 1 part (ii).

■

Proof of Proposition 1 Part (iv).

We first show that $\overline{\theta} \leq x_B^*(1) \leq \hat{d}$ and $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$ are necessary conditions for the existence of the separating equilibrium described in part (ii). Next we show that under those conditions, a separating equilibrium does exist. Finally, we discuss the conditions for uniqueness.

Step 1: First, we suppose the product-driven entrepreneur creates a project on the platform and both entrepreneurs expect to reach their funding goal, then we back out the conditions for the above holds. By the proof of Lemma 2, Condition (3) must hold in equilibrium. Condition (3) now becomes

$$0 \leq \mathrm{E}_{t'}\left[s_B^*(0)\right] - \mathrm{E}_{t'}\left[s_B^*(1)\right] \leq (d - x_B^*(0))^2 - (d - x_B^*(1))^2. \tag{6}$$

Lemma 2 also suggests $x_B^*(0) \leq x_B^*(1)$, and thus by definition of separating equilibrium, we have $x_B^*(0) < x_B^*(1)$. Moreover, in any separating equilibrium, $x_B^*(0) = 0$. This is because in any separating equilibrium, $\mu_B(x^*(0)) = 1$, and thus fixing type 1 entrepreneur B's strategy, the expected utility of type 0 entrepreneur B choosing location $x_B(0)$ is $p\mathrm{E}_{t'}[s_B(0)]$ where

$$\begin{aligned}\mathrm{E}_{t'}[s_B(0)] = \mathrm{E}_{t'}\left[\frac{1}{2} - \frac{x_A^*(t') + x_B(0)}{4} - \frac{M_A(t') - M_B(0)}{4(x_A^*(t') - x_B(0))}\right] = \frac{1}{2} - \lambda\frac{x_A^*(0) + x_B(0)}{4} \\ - (1-\lambda)\left[\frac{x_A^*(1) + x_B(0)}{4} - \frac{1 - (1 - q^*(1))^2}{4(x_A^*(1) - x_B(0))}\right]. \end{aligned} \tag{7}$$

Note that

$$\frac{\partial \mathrm{E}_{t'}[s_B(0)]}{\partial x_B(0)} = -\frac{1}{4} + \frac{(1-\lambda)\left(1 - (1 - q^*(1))^2\right)}{4(x_B(0) - x_A^*(1))^2} = -\frac{1}{4} + \frac{\underline{\theta}}{4(x_B(0) - x_A^*(1))^2} < 0$$

if and only if $x_B(0) > \underline{\theta}+x_A^*(1)$. Thus the expected utility of type 0 entrepreneur B is decreasing in $x_B(0)$ if $x_B(0) > \underline{\theta} + x_A^*(1)$, and increasing in $x_B(0)$ if $x_B(0) < \underline{\theta} + x_A^*(1)$. Therefore, if $\underline{\theta} + x_A^*(1) \leq 0$, i.e., $x_A^*(1) \leq -\underline{\theta}$, then by $x_B(0) \geq 0$, the optimal location for type 0 entrepreneur B is $x_B^*(0) = 0$. If $x_A^*(1) > -\underline{\theta}$, then the optimal location for type 0 entrepreneur B is $x_B^*(0) = \underline{\theta} + x_A^*(1)$. Following the same logic, we can show $x_A^*(0) = 0$ if $x_B^*(1) \geq \underline{\theta}$ otherwise $x_A^*(0) = x_B^*(1) - \underline{\theta}$. Since the environment is symmetric, type t entrepreneur A and B must choose locations that are symmetric around zero. That is, $-x_A^*(0) = x_B^*(0) = x^*(0)$ and $-x_A^*(1) = x_B^*(1) = x^*(1)$. Otherwise, the incentive compatibility constraints for type t entrepreneur A and B cannot hold at the same time given the symmetric environment. For the separating equilibrium to exist, Condition (6) must be satisfied. In what follows, we consider when Condition (6) holds in the cases where $x^*(0) = \underline{\theta} - x^*(1)$ and $x^*(0) = 0$.

Case 1 $x^*(0) = \underline{\theta} - x^*(1) > 0$. Note that the expected market share of type 0 entrepreneur B is

$$\begin{aligned}
\mathrm{E}_{t'}[s_B(0)] &= \frac{1}{2} - \lambda\frac{x_A^*(0) + x_B^*(0)}{4} - (1-\lambda)\left[\frac{x_A^*(1) + x_B^*(0)}{4} - \frac{1-(1-q^*(1))^2}{4(x_A^*(1) - x_B^*(0))}\right]. \\
&= \frac{1}{2} + (1-\lambda)\left[\frac{x^*(1) - x^*(0)}{4} - \frac{1-(1-q^*(1))^2}{4(x^*(1) + x^*(0))}\right] \\
&= \frac{1}{2} + (1-\lambda)\frac{x^*(1) - x^*(0)}{4} - \frac{\underline{\theta}^2}{4(x^*(1) + x^*(0))}
\end{aligned}$$

The expected market share of type 1 entrepreneur B is

$$\begin{aligned}
\mathrm{E}_{t'}[s_B(1)] &= \frac{1}{2} - \lambda\left[\frac{x_A^*(0) + x_B^*(1)}{4} + \frac{1-(1-q^*(1))^2}{4(x_A^*(0) - x_B^*(1))}\right] - (1-\lambda)\left[\frac{x_A^*(1) + x_B^*(1)}{4}\right] \\
&= \frac{1}{2} - \lambda\frac{x^*(1) - x^*(0)}{4} + \lambda\frac{\overline{\theta}^2}{4(x^*(0) + x^*(1))}
\end{aligned}$$

In the case where $x^*(0) = \underline{\theta} - x^*(1) > 0$,

$$\begin{aligned}
\mathrm{E}_{t'}[s_B(0)] - \mathrm{E}_{t'}[s_B(1)] &= \frac{x^*(1) - x^*(0)}{4} - (1 + \frac{\lambda}{1-\lambda})\frac{\underline{\theta}^2}{4(x^*(1) + x^*(0))} \\
&= \frac{2x^*(1) - \underline{\theta}}{4} - (1 + \frac{\lambda}{1-\lambda})\frac{\underline{\theta}}{4} \text{ (by } x^*(1) < \underline{\theta}) \\
&\leq \frac{\underline{\theta}}{4} - (1 + \frac{\lambda}{1-\lambda})\frac{\underline{\theta}}{4} \text{ (by } x^*(0) = \underline{\theta} - x^*(1)) \\
&< 0,
\end{aligned}$$

which contradicts with Condition (6) that $\mathrm{E}_{t'}[s_B(0)] - \mathrm{E}_{t'}[s_B(1)] \geq 0$. Thus, in this case, separating equilibrium does not exist.

Case 2 $x^*(0) = 0$ and $x^*(1) \geq \underline{\theta}$. In this case,

$$\mathrm{E}_{t'}[s_B(0)] - \mathrm{E}_{t'}[s_B(1)] = \frac{x_1^*}{4} - \frac{1 - (1 - q_1^*)^2}{4x_1^*} = \frac{1}{4}\left(x_1^* - \frac{\overline{\theta}^2}{x_1^*}\right).$$

Substituting the above into Condition (6), we obtain a necessary condition for the existence of a separating equilibrium in this case:

$$0 \leq \frac{1}{4}\left(x^*(1) - \frac{\overline{\theta}^2}{x^*(1)}\right) \leq [d^2 - (d - x^*(1))^2]. \tag{8}$$

The left inequality implies $x^*(1) \geq \overline{\theta}$. Note that any strategy with $x(1) > d$ is dominated by $x(1) = d$ and all else equal, because moving to B's ideal location would increase the market share and incur less utility loss from the ideal location. As a result, in equilibrium $x(1)^* \leq d$ and, in turn, we have $d \geq x^*(1) \geq \overline{\theta}$.

Thus, in any separating equilibrium, we must have $x^*(0) = 0$ and $x^*(1) \geq \overline{\theta}$.

Now we consider when product-driven entrepreneurs would create a project. In a separating equilibrium, the funding goal of a product-driven entrepreneur e should be $G^*(1) = \phi p s_e^* + \frac{\gamma}{(1+\gamma)^2}$, because a lower funding goal would result in negative profit and a higher funding goal would decrease the probability of project success. Therefore, for the product-driven entrepreneur e to reach the funding goal, it must be $ps_e^* \geq \phi ps_e^* + \frac{\gamma}{(1+\gamma)^2}$ or equivalently, $\underline{s}(\phi) \equiv \frac{\gamma}{(1-\phi)p(1+\gamma)^2} \leq s_e^*$. For such separating equilibrium to exist, type 1 entrepreneur must at least obtain $\underline{s}$ market share. That is,

$$\mathrm{E}_{t'}[s_B(1)] = \frac{1}{2} - \lambda\frac{x^*(1)}{4} + \lambda\frac{\overline{\theta}^2}{4x^*(1)} \geq \underline{s}(\phi),$$

or equivalently

$$x^*(1) \leq \frac{1 - 2\underline{s}(\phi) + \sqrt{(1-2\underline{s}(\phi))^2 + \lambda^2\overline{\theta}^2}}{\lambda}.$$

By Condition (6) and symmetry, $\mathrm{E}_{t'}[s_B(1)] \leq \frac{1}{2}$. As a result, a product-driven entrepreneur would create a project if $\mathrm{E}_{t'}[s_B(1)] \geq \underline{s}(\phi)$ and thus $\underline{s}(\phi) \leq \frac{1}{2}$. As a result,

$$\frac{1 - 2\underline{s}(\phi) + \sqrt{(1-2\underline{s}(\phi))^2 + \lambda^2\overline{\theta}^2}}{\lambda} \geq \frac{\sqrt{\lambda^2\overline{\theta}^2}}{\lambda} = \overline{\theta}.$$

Therefore, a separating equilibrium exists only if

$$\hat{d} \equiv \min\left\{\frac{1 - 2\underline{s}(\phi) + \sqrt{(1-2\underline{s}(\phi))^2 + \lambda^2\overline{\theta}^2}}{\lambda}, d\right\} \geq x^*(1) \geq \overline{\theta},$$

and $\underline{s}(\phi) = \frac{\gamma}{(1-\phi)p(1+\gamma)^2} \leq \frac{1}{2}$ or equivalently, $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$.

Step 2: In this step, we show when $d \in [\overline{\theta}, 1]$ and $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$, there exists a separating equilibrium. That is, there exists on $x^*(1) \neq x^*(0)$ such that the separate equilibrium exists. If so, then (i) $x^*(1) \in [\overline{\theta}, \hat{d}]$; and (ii) $x^*(1)$ (resp., $-x^*(1)$) is a best response of product-driven entrepreneur B (resp., A).

By Condition D1, if backers observe any deviation $x' \in [\overline{\theta}, \hat{d}]$, then $\mu_B(x') = 0$, i.e., backers believe the deviator to be of type 1 with probability one. This is because it is less profitable for type 0 entrepreneur B to deviate from $x_0^* = 0$ to any $x' \in [\overline{\theta}, \hat{d}]$ than for type 1 entrepreneur B. As a result, it would not change backers' belief about entrepreneur B if she deviates from $x^*(1)$ to any $x'' \in X_{se}$. Therefore, $x^*(1)$ solves the following optimization problem:

$$x^*(1) \in \arg\max_{x' \in [\overline{\theta}, \hat{d}]} \mathrm{E}_{t'}[u_B(x', G_B^*, q^*(1))]. \tag{9}$$

We define the set of such $x^*(1)$ by X_1^*. In what follows, we show that X_1^* is nonempty.

First, we show in step 1 that $\overline{\theta} \leq \hat{d}$, so $[\overline{\theta}, \hat{d}]$ is nonempty and compact. We now turn to Condition (9). Recall that:

$$\mathrm{E}_{t'}[u_B(x', G_B^*, q^*(1))] = -[(d - x')^2 - (1 - q^*(1))^2] + \mathrm{E}_{t'}[s(1; x')] - \gamma q^*(1)^2,$$

where

$$\mathrm{E}_{t'}[s(1; x')] = \frac{1}{2} - \frac{x'}{4} + \lambda \frac{1 - (1 - q^*(1))^2}{4x'} + (1 - \lambda)\frac{x^*(1)}{4}.$$

Rearrange the terms of Condition (9):

$$x_1 \in \arg\max_{x' \in [\overline{\theta}, \hat{d}]} \left\{ -(d - x')^2 - \frac{x'}{4} + \lambda \frac{1 - (1 - q^*(1))^2}{4x'} \right\}. \tag{10}$$

Define the objective function by $H(x')$:

$$H(x') = -(d - x')^2 - \frac{x'}{4} + \lambda \frac{1 - (1 - q^*(1))^2}{4x'}. \tag{11}$$

Since $H(\cdot)$ is continuous and $[\overline{\theta}, \hat{d}]$ is compact, by the Weierstrass Theorem there must exist a solution to the optimization problem defined by Condition (10). That is, X_1^* is nonempty. Therefore, a separating equilibrium exists if the conditions in Proposition 1 part (iv) hold.

In that equilibrium, a product-driven entrepreneur expects to earn a market share

$$\mathrm{E}_{t'}[s_B(1)] = \frac{1}{2} - \frac{\lambda x^s(1)}{4} + \frac{\lambda \overline{\theta}^2}{4x^s(1)},$$

for any $x^s(1) \in X_1^*$. As a result, a product-driven entrepreneur would choose a funding goal

$$G^*(1) = \phi p \left[\frac{1}{2} - \frac{\lambda x^s(1)}{4} + \frac{\lambda \overline{\theta}^2}{4x^s(1)} \right] + \frac{\gamma}{(1+\gamma)^2}.$$

A profit-driven entrepreneur expect to earn a market share

$$\mathrm{E}_{t'}[s_B(0)] = \frac{1}{2} + \frac{(1-\lambda)x^s(1)}{4} - \frac{\underline{\theta}^2}{4x^s(1)}$$

for any $x^s(1) \in X_1^*$. As a result, a profit-driven entrepreneur would choose a funding goal

$$G^*(0) = \phi p \left[\frac{1}{2} + \frac{(1-\lambda)x^s(1)}{4} - \frac{\underline{\theta}^2}{4x^s(1)} \right]$$

■

Proof of Proposition 1 Part (iii).

Proposition 1 parts (ii) and (iv) show that there does not exist a separating or a pooling equilibrium if $d \in (\underline{\theta}, \overline{\theta})$ and $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$. We now show that there is a unique hybrid equilibrium if $d \in (\underline{\theta}, \overline{\theta})$ and $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$.

Suppose the hybrid equilibrium exists. Then by Condition D1, we have $|x_e^*(1)| = d$ in the hybrid equilibrium. Without loss of generality, let's consider entrepreneur B. When product-driven entrepreneur B separates from the profit-driven, any strategy with $x_B(1) = x^* \neq d$ is dominated by the strategy with $x_B(1) = x'$ given all else equal, where x' is ε closer to d, i.e., $(x' - d)^2 - \varepsilon = (x^* - d)^2$ where $\varepsilon \to 0$. Choosing a location closer to his ideal location further renders the product-driven entrepreneur better off from the location preference; additionally by Lemma 4, this makes $\mu_B(x', G_B) = 0$, and thus increases market share (by Lemma 3).

Moreover, by Equation (7), profit-driven entrepreneur B would only assign positive probability to choose $x_B(0) = x^*(1)$ and $x_B(0) = 0$ in equilibrium. All else equal, suppose profit-driven entrepreneur B chooses location $x' \neq x^*(1)$; then, by Equation (7), we have

$x_B(0) = 0$ maximizes profit-driven entrepreneur B's expected utility. As a result, profit-driven entrepreneur B would only assign zero probability to any $x_B(1) \neq 0$ or $x^*(1)$.

Consequently, if there exists a hybrid equilibrium, we write the equilibrium as $\boldsymbol{\sigma} = (\sigma^*(0,-d), -d, \boldsymbol{G^*}, \boldsymbol{q}^*; \sigma^*(0,d), d, \boldsymbol{G^*}, \boldsymbol{q}^*)$, where $\sigma(0,d)$ (respectively, $\sigma(0,-d)$) represents the probability the entrepreneur assigns to choose location 0 and funding goal $G^*(0)$, and thus $1-\sigma(0,d)$ (respectively, $1-\sigma(0,-d)$) represents the probability the entrepreneur assigns to location$d$ (respectively, $-d$) and funding goal $G^*(1)$. By symmetry, in equilibrium, $\sigma^*(0,d) = \sigma^*(0,-d)$. For ease, write $\sigma^* = \sigma^*(0,d) = \sigma^*(0,-d)$.

Next, we show there exists an equilibrium with $\sigma^* \in (0,1)$. Then by Bayes rule, backers' posterior about entrepreneur B's type—the probability that entrepreneur B is profit-driven—is

$$\mu_B(0, G_B) = 1 \text{ and } \mu_B(d, G_B) = \frac{(1-\sigma^*)\lambda}{1-\sigma^*\lambda}.$$

Notice that if profit-driven entrepreneur is willing to randomize between $x_B(0) = 0$ and $x_B(0) = d$, it must be that she is indifferent between $x_B(0) = 0$ and $x_B(0) = d$. By Lemma 3, the expected market share of profit-driven entrepreneur B choosing $x_B(0) = 0$ is

$$\sigma^*\lambda\frac{1}{2} + (1-\sigma^*\lambda)\left[\frac{1}{2} + \frac{d}{4} - \frac{(1-\lambda)\overline{\theta}}{4d(1-\sigma^*\lambda)}\right], \tag{12}$$

and the expected utility of profit-driven entrepreneur B choosing $x = d$ is

$$\sigma^*\lambda\left[\frac{1}{2} - \frac{d}{4} + \frac{(1-\lambda)\overline{\theta}}{4d(1-\sigma^*\lambda)}\right] + (1-\sigma^*\lambda)\frac{1}{2}. \tag{13}$$

Equalize Equation (12) and Equation (13) and we have

$$\sigma^* = \frac{1}{\lambda}\left[1 - \frac{(1-\lambda)(1-(1-q^*(1))^2)}{d^2}\right].$$

By $\underline{\theta} < d < \overline{\theta}$, it is easy to check

$$\sigma^* = \frac{1}{\lambda}\left[1 - \frac{\underline{\theta}^2}{d^2}\right] > 0,$$

and

$$\sigma^* = \frac{1}{\lambda}\left[1 - (1-\lambda)\frac{\overline{\theta}^2}{d^2}\right] < \frac{1}{\lambda}\left[1 - (1-\lambda)\right] = 1.$$

In this case, profit-driven entrepreneur B expects to earn a market share

$$\mathrm{E}_{t'}[s_B(0)] = \sigma^*(12) - (1-\sigma^*)(13) = (13) = \mathrm{E}_{t'}[s_B(1)] = \frac{1}{2}.$$

Therefore, product-driven entrepreneur would create a project if and only if $\frac{1}{2} \geq \frac{\gamma}{(1-\phi)p(1+\gamma)^2}$ or equivalently, $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$. In the meantime, the profit-driven entrepreneur would choose $G^*(0) = \frac{\phi p}{2}$ with probability σ^*, and $G^*(0) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$ with probability $1 - \sigma^*$. Type 1 entrepreneur would choose a funding goal $G^*(1) = \frac{\phi p}{2} + \frac{\gamma}{(1+\gamma)^2}$. ■

Proof of Proposition 1 Part (i). From the proofs of Proposition 1 (ii)-(iv), we immediate obtain that a product-driven entrepreneur creates a project on the platform if $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$. Thus if $\phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}$, no product-driven entrepreneur would create a project on the platform. ■

Proof of Proposition 2. Note that the platform's payoff is

$$v = \phi p(1 + \eta(\bar{Q})).$$

We discuss the following four cases, respectively.

Case (i) $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$ and $d \leq \underline{\theta}$. In this case, the average quality of the products on the platform is

$$\bar{Q}^p = (1-\lambda)q(1)^* = \frac{(1-\lambda)\gamma}{(1-\phi)p(1+\gamma)^2}$$

which is independent of ϕ. Then the platform's payoff, $\phi p(1 + \eta(\bar{Q}^p))$, is strictly increasing in ϕ. Thus, the optimal commission rate is $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$.

Case (ii) $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$ and $d \geq \overline{\theta}$. In this case, the average quality of the products on the platform is

$$\bar{Q}^s = \left[1 + \lambda - \lambda x^s(1) - \frac{\lambda \overline{\theta}^2}{x^s(1)}\right] \frac{(1-\lambda)\gamma}{(1-\phi)p(1+\gamma)^2}.$$

Note that, as ϕ increases, $x^s(1)$ weakly decreases because $\hat{d}$ is weakly decreasing in ϕ. Note that $\bar{Q}^s$ is decreasing in $x(1)^s$, and so is weakly increasing in ϕ. As a result, the platform's payoff, $\phi p(1 + \eta(\bar{Q}^s))$, is strictly increasing in ϕ. Thus, the optimal commission rate is $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$.

Case (iii) $\phi \leq 1 - \frac{2\gamma}{p(1+\gamma)^2}$ and $\underline{\theta} \leq d \leq \overline{\theta}$. In this case, the average quality of the products on the platform is

$$\bar{Q}^h = (1-\lambda)q(1)^* = \frac{(1-\lambda)\gamma}{(1-\phi)p(1+\gamma)^2}$$

It is independent of ϕ. Then the platform's payoff is strictly increasing in ϕ. Thus, the optimal commission rate is $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$.

Case (iv) $\phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}$ Then in this case the product-driven entrepreneurs would not create any project. But profit-driven entrepreneurs still do, and thus the average quality of the projects on the platform is $\bar{Q} = 0$. Then the platform's payoff is $\phi p(1 + \eta(0))$. Note that $\min\{\eta(\bar{Q}^p), \eta(\bar{Q}^s), \eta(\bar{Q}^h)\} = \eta(Q^s)$. The platform would charge a commission $\phi > 1 - \frac{2\gamma}{p(1+\gamma)^2}$ only if $\phi(1 + \eta(0)) > \phi^*(1 + \eta(\bar{Q}^s))$. Since $\phi \in [0,1]$, platform would charge commission ϕ^* if $1 + \eta(0) < \phi^*(1 + \eta(\bar{Q}^s))$, or equivalently $\eta(0) < \bar{\eta}$, where

$$\bar{\eta} \equiv \left[1 - \frac{2\gamma}{p(1+\gamma)^2}\right] \eta\left(\left(1 + \lambda - \lambda x^s(1) - \frac{\lambda\overline{\theta}^2}{x^s(1)}\right) \frac{(1-\lambda)\gamma}{(1-\phi)p(1+\gamma)^2}\right) - \frac{2\gamma}{p(1+\gamma)^2}.$$

To sum up, if $\eta(0) < \bar{\eta}$, the optimal commission rate is $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$. ■

Proof of Proposition 3. Note that under ϕ^*, product-driven entrepreneurs create projects on the platform, so part (i) and (iii) immediately follows from Proposition 1 (ii) and (iii). Thus we only need show Part (iii): if $d \in [\overline{\theta}, 1]$, there is a unique separating equilibrium as describe in Corollary 3 part (iii). Substituting $\phi^* = 1 - \frac{2\gamma}{p(1+\gamma)^2}$ into $\underline{s}$ yields $\underline{s} = \frac{1}{2}$. Then $\hat{d} = \min\{\overline{\theta}, d\} = \overline{\theta}$ and $x^*(1) \in [\overline{\theta}, \overline{\theta}]$, or equivalently $x^*(1) = \overline{\theta}$. Therefore, the separating equilibrium is unique. Substituting $x^*(1) = \overline{\theta}$ to Proposition 1 part (iii) yields the funding goals described in Corollary 3 part (iii).

■

Appendix B Condition D1

In this section, we define condition D1 in our context, and establish results that are useful for the proofs of our propositions. Note that by backward induction and Lemma 1, $q_e^*(t)$ is pinned down given entrepreneur e's type 1. So we consider the equilibrium refinement regarding the off-equilibrium path beliefs for deviations of location and funding goal.

Consider an equilibrium $(x_A^*(t_A), G_A^*(t_A), q^*(t_A); x_B^*(t_B), G_B^*(t_B), q^*(t_B))$ for $t_A, t_B \in \{0, 1\}$. Let $r_A^* = (x_A^*(t_A), G_A^*(t_A), q_A^*(t_A))$. Suppose type t entrepreneur B's deviates to location and funding goal $(x', G') \neq (x_B^*(t), G_B^*(t))$ on the off-equilibrium path. For any such deviation (x', G') on the off-equilibrium-path, we define the strictly preferred defection set of type t entrepreneur B:

$$R_B\left((x', G')\,|t\right) = \{\mathrm{E}_{t_A}[s_B^*(x', G', q^*(t); r_A^*)]\,|\mathrm{E}_{t_A}[u_B(x, G, q^*(t); r_A^*)] < \mathrm{E}_{t_A}[u_B(x', G', q^*(t); r_A^*)]\}\,;$$

and the indifference defection set of type t entrepreneur B:

$$R_B^\circ\left((x', G')\,|t\right) = \{\mathrm{E}_{t_A}[s_B^*(x', G', q^*(t); r_A^*)]|\mathrm{E}_{t_A}[u_B(x, G, q^*(t); r_A^*)] = \mathrm{E}_{t_A}[u_B(x', G', q^*(t); r_A^*)]\}\,,$$

where $s_B^*(x', G', q^*(t); r_A^*)$ is entrepreneur's market share function that aggregates backers' best responses to the entrepreneurs' choices of locations and funding goals.

Condition D1. *Backers assign* 0 *probability to entrepreneur* B *being type* t *if* $R_B(x'|t) \cup R^{\circ}_B(x'|t) \subseteq R_B(x'|t')$ *for* $t' \neq t$, *and* $t' \in \{0, 1\}$.

Lemma 4 summarizes the requirement of Condition D1 in the pooling equilibrium.

Lemma 4. *Suppose there is a deviation of entrepreneur* B *from equilibrium strategy* (x, G) *to* (x', G) *on the off-equilibrium-path. Suppose all type entrepreneurs would create projects on the platform given funding goal* G. *Then Condition D1 requires that*

(i) if $|x' - d| < |x - d|$, *then* $\mu(x', G) = 0$; *and*

(ii) if $|x' - d| > |x - d|$, *then* $\mu(x', G) = 1$.

Lemma 4 suggests that backers would assign probability one to a deviator being profit-driven if she deviates away from his ideal location, and assign probability one to a deviator being product-driven if she deviates toward his ideal location. This is because a profit-driven entrepreneur is more profitable, and thus more likely to deviate away from his ideal location. A product-driven entrepreneur, however, is profitable, and thus more likely to deviate toward his ideal location. As a consequence, when backers see a deviation toward (respectively, away from) his ideal location, backers would believe the deviator to be product-driven (respectively, profit-driven) with higher chance. Condition D1 takes the logic to the limit, so that backers believe the deviator to be product-driven (respectively, profit-driven) with probability one.

Proof.

Deviation toward ideal location. First, we consider a deviation from (x, G) to (x', G) such that $|x' - d| < |x - d|$. The expected utility difference of entrepreneur B moving from

x to x' is

$$\Delta_t = \mathrm{E}_{t_A}[u_B(x', G, q^*(t); r_A^*)] - \mathrm{E}_{t_A}[u_B(x, G, q^*(t); r_A^*)] =$$
$$- t[(d-x')^2 - (d-x)^2] + \mathrm{E}_{t_A}[s_B^*(x', G, q^*(t); r_A^*) - \mathrm{E}_{t_A}[s_B^*(x, G, q^*(t); r_A^*),$$

and

$$\Delta_1 - \Delta_0 = -[(d-x')^2 - (d-x)^2] > 0.$$

This is because for the same location, backers would have the same posterior, and thus the same best response fixing A's strategy. Therefore, for any $\mathrm{E}_{t_A}[s_B^*(x', G, q^*(t); r_A^*)$ and $\mathrm{E}_{t_A}[s_B^*(x, G, q^*(t); r_A^*)$ such that $\Delta_0 \geq 0$, it must be that $\Delta_1 > 0$. Thus, $R_B(x'|0) \cup R_B^\circ(x'|0) \subseteq R_B(x'|1)$. Therefore, for any deviation toward the ideal location, backers believe the deviator is of profit-driven with probability 0, i.e. $\mu(x', G) = 0$.

Deviation away from the ideal location. Now, instead, we consider a deviation from (x, G) to (x', G) such that $|x' - d| > |x - d|$. Analogously, we have

$$\Delta_0 - \Delta_1 = (d-x')^2 - (d-x)^2 > 0.$$

Therefore, for any $\mathrm{E}_{t_A}[s_B^*(x', G, q^*(t); r_A^*)$ and $\mathrm{E}_{t_A}[s_B^*(x, G, q^*(t); r_A^*)$ such that $\Delta_1 \geq 0$, it must be that $\Delta_0 > 0$. Thus, $R_B(x'|1) \cup R_B^\circ(x'|1) \subseteq R_B(x'|0)$. Therefore, for any deviation away from the ideal location, backers believe the deviator is of product-driven with probability 0 and so believe the deviator is of profit-driven with probability 1, i.e., $\mu(x', G) = 1$.

■