Learning from and Disclosing to the Crowd

Lin Nan	Chao Tang	Xin Wang	Gaoqing Zhang
Purdue	HKUST	HKUST	Minnesota
lnan@purdue.edu	actang@ust.hk	xinwang@ust.hk	zhangg@umn.edu

October 2019

Abstract

We investigate the role of mandatory disclosure in crowdfunding markets. Our analysis identifies that crowdfunding provides a benefit for an entrepreneur to learn consumers' preferences before deciding whether to launch an innovative product. However, the crowdfunding market also features an under-implementation inefficiency, driven by two types of uncertainty that consumers face: *fundamental uncertainty* about the entrepreneur's implementation cost, and *strategic uncertainty* due to potential coordination failures among consumers. We find that, the mandatory disclosure of the implementation cost, although eliminates the fundamental uncertainty, may not necessarily mitigate the strategic uncertainty. We obtain a somewhat surprising result that, from an *ex-ante* perspective, mandating disclosure actually makes it even less likely for the entrepreneur to implement the new product than without disclosure, thus impairing efficiency.

1 Introduction

Crowdfunding, a new avenue for entrepreneurs to finance their early-stage projects, has gained great interest in recent years. Using the internet, entrepreneurs can extend their reach to the general public (the so-called "crowds"), making it much easier to finance new ideas and technologies. According to the report by *Statista*, the total number of crowdfunding campaigns worldwide amounts to 6.45 million in 2018. As the crowdfunding market grows exponentially in size, it also draws considerable attention from regulators who usually supervise traditional financial markets. Most notably, the Security and Exchange Commission (SEC) has mandated a number of disclosure requirements in the hope of promoting transparency and protecting investors.[1] Yet, most of the pro-transparency arguments are based on lessons from traditional financial markets. Caution must be taken when one applies these lessons to the new and different crowdfunding market. In this light, this paper examines the role of mandatory disclosure in the crowdfunding market. We find that, in contrast to its usual beneficial role in traditional markets, greater disclosure may discourage crowdfunding participation and even hinder innovation.

The key economic mechanism behind the adverse effect of disclosure is that crowdfunding plays a special role in providing early feedback to the entrepreneur about the new product. Many believe that such feedback effects constitute a major benefit of crowdfunding.[2] The feedback effects arise because, different from monetary returns to traditional investments, returns to crowdfunding investments are typically reward-based: crowdfunding investors are

[1] See Regulation Crowdfunding, https://www.sec.gov/files/2017-03/RegCF_WhitePaper.pdf. For instance, the SEC requires entrepreneurs to provide "a description of the purpose and intended use of the offering proceeds," "a discussion of the material factors that make an investment in the issuer speculative or risky," and "a description of the ownership and capital structure of the issuer," etc.

[2] The following example may illustrate the importance of learning in crowdfunding markets. Danae Ringelmann, the founder of Indiegogo, commented "(w)e've actually gotten thank you notes from people who were highly unsuccessful in raising money that said, 'In three weeks I discovered that I had an idea that nobody wanted. You just saved me two years of my life.' " (quoted from Xu, 2018) A recent empirical study by Xu (2018) also shows that more positive feedback in crowdfunding markets increases entrepreneurs' chances to continue their projects.

promised a new product which an entrepreneur intends to develop with the funds raised from the crowdfunding campaign. In this light, crowdfunding investors are also early consumers of the entrepreneur's product. How enthusiastic they are in pre-ordering the new product thus helps the entrepreneur to gauge how well the product will sell later in mass markets. A key finding of our paper is that, once taking into account the feedback role of crowdfunding, more disclosure is not always beneficial.

Our paper examines a setting in which an entrepreneur is considering whether to implement/launch a new product, facing an uncertainty regarding the market taste. Launching the product can be very costly. We assume that the launching/implementation cost is privately known only to the entrepreneur. Prior to the launch, the entrepreneur can test the market through crowdfunding. Each crowdfunding consumer privately observes his preference/taste for the product and decides how much to pre-order. After receiving total pre-orders from the crowdfunding market, the entrepreneur determines whether to launch the product. Once the product is launched, she sells it also in a traditional mass market.

We first consider a regime in which the entrepreneur does not reveal the implementation cost. Our analysis identifies that crowdfunding provides a benefit for the entrepreneur to learn the market taste before deciding whether to launch the product. The entrepreneur rationally anticipates that each consumer takes into account his own taste in submitting the pre-order. When aggregated, these pre-orders reflect how favorable the market taste is. That information in turn helps the entrepreneur to better forecast her future profits if she launches the product and sells in the traditional mass market. In equilibrium, the entrepreneur will launch the product if and only if she observes a sufficiently favorable response in the crowdfunding market.

Nonetheless, our analysis shows that, despite the feedback benefit, the crowdfunding market also features an inefficiency. That is, compared with a complete-information benchmark, the entrepreneur is less likely to launch the new product due to the underparticipation by crowdfunding consumers. Two types of uncertainty that consumers face

contribute to this inefficiency. First, absent disclosure, there is *fundamental uncertainty* about the entrepreneur's implementation cost, and each crowdfunding consumer can only rely on his prior belief about the cost to infer the chance of product launch. Second, there also exists *strategic uncertainty* regarding other consumers' decisions. More specifically, since the entrepreneur relies on the total pre-orders to obtain feedback, inferring the chance of product launch requires each consumer to gauge others' pre-orders. Each consumer, therefore, decides whether to participate in crowdfunding by evaluating not only his own taste for the product, but also others' pre-orders. That is, the feedback role of crowdfunding makes consumers' pre-order decisions strategic complements in the sense that a consumer pre-orders more when others do the same. However, since consumers do not observe others' tastes, they face strategic uncertainty in forecasting and coordinating with others' decisions. Therefore, a consumer may decide not to pre-order even if he prefers the product but fears that others may not think so. We find that, the two types of uncertainty faced by consumers collectively reduce their pre-orders, resulting in interruptions of innovation that should have been developed absent such uncertainty.

Given the two types of uncertainty that lead to the entrepreneur's under-implementation inefficiency, we examine whether mandatory disclosure of the implementation cost could alleviate the inefficiency. One may conjecture that, as disclosure reduces the uncertainty faced by consumers, it should help to improve efficiency. We find that this conjecture is not true. While disclosure of the implementation cost eliminates the fundamental uncertainty, it may not necessarily mitigate the strategic uncertainty. We obtain a somewhat surprising result that, from an *ex-ante* perspective, mandating disclosure actually aggravates the under-implementation problem, thus impairing efficiency.

The intuition for our result lies in how disclosure affects the strategic uncertainty for consumers and alters the coordination among them. A favorable disclosure of a low implementation cost helps consumers to coordinate on an equilibrium in which the demand in the crowdfunding market is strong, and the entrepreneur is highly likely to launch the

new product. However, an unfavorable disclosure of a high cost leads to the opposite case with a weak crowdfunding market demand and a low likelihood of product launch. That is, disclosure coordinates the equilibrium actions of both the entrepreneur and consumers to be more extreme. Nonetheless, there is an asymmetry in the coordination effects of disclosing a low cost versus a high cost. The beneficial effect of disclosing a low cost is limited in its magnitude by the fact that a low-cost entrepreneur is already very likely to launch the product, regardless of the feedback from the crowds. In contrast, the detrimental effect of disclosing a high cost is quite substantial. The reason is that a high-cost entrepreneur is keen on the feedback from the crowdfunding market to gauge whether to launch the product. In fact, she will not launch the product unless receiving overwhelmingly strong crowdfunding demands. In this light, disclosing her high cost significantly dampens the crowdfunding demands and deters the entrepreneur from innovating. Because of the asymmetry, *ex ante*, mandatory disclosure always impedes entrepreneurial innovation.

2 Related Literature

Our paper is built on a burgeoning literature on crowdfunding (Agrawal, Catalini, and Goldfarb, 2014; Mollick, 2014; Belleflamme, Omrani, and Peitz 2015; Xu, 2018; Madsen and McMullin, 2018). More related to our study, two recent papers have also examined the feedback role of crowdfunding. Strausz (2017) shows that, while crowdfunding leads to an efficiency gain and allows the entrepreneur to learn information about market demands, it can be beneficial to restrict such learning when there is a moral hazard problem that the entrepreneur may embezzle investment funds. Chemla and Tinn (forthcoming) examine a similar setting with both learning and moral hazard, yet reach a different conclusion. They find that the value of learning through crowdfunding can help firms to endogenously overcome moral hazard. Our paper abstracts away from the well-studied moral hazard issues and focuses instead on two other aspects of crowdfunding that none of the prior

studies have examined. First, we show that the feedback role of crowdfunding may induce consumers to coordinate their crowdfunding decisions, which leads to strategic uncertainty and hampers crowdfunding participations. Second, we examine the economic consequences of recent disclosure regulation in crowdfunding markets and find that mandatory disclosure can hinder entrepreneurial innovation.

More broadly, our paper is related to the extensive accounting and economics literature that examines the effect of information disclosure in financial markets (see Beyer, Cohen, Lys and Walther (2010) for a recent survey). A main insight from this literature is that, better disclosure in the financial market is generally beneficial and improves efficiency. We show that such benefits may not extend to the new and different crowdfunding market. We find that mandating more disclosure by crowdfunding firms can deter consumers from participating in crowdfunding and deter entrepreneurs from innovations. Such "real effects" of disclosure, albeit derived in a different context, echoes the "real effects hypothesis" in Kanodia and Sapra (2016) that "(i)f how accountants measure and disclose a firm's economic transactions changes those transactions, then it is not necessarily true that any disclosure that is incrementally informative to the capital market improves resource allocation."

To the extent that we study the coordination effect of disclosure in the crowdfunding market, our paper is also related to a stream of literature on the role of information in economies that feature coordination motives (see Angeletos and Lian (2016) for a recent survey). For instance, Allen, Morris and Shin (2006) and Gao (2008) examine the coordination role of disclosure in "Keynesian-beauty-contest" financial markets. Gao and Jiang (2018), Zhang (2018), and Liang and Zhang (2019) examine the coordination role of accounting disclosure in bank runs. Corona, Nan, and Zhang (2019) consider the coordination role of stress-test disclosure in a setting that banks take excessive amounts of risk anticipating the prospect of bailouts. We extend this literature to a crowdfunding context and show that the feedback role of crowdfunding also gives rise to a coordination role of disclosure.

3 The Model

We consider a setting in which an entrepreneur seeks funds for launching an innovative project, for example, a new product, in the crowdfunding market.[3] There is an implementation cost to launch the new product, c, which is private information of the entrepreneur, while outsiders only have the prior belief that the implementation cost follows a uniform distribution in the interval $[0, \overline{c}]$. The implementation cost could be interpreted as, for example, costs or difficulty level of R&D for the new product, and it may include not only monetary costs but also non-monetary costs. We assume that the upper bound for the implementation cost, $\overline{c}$, is not too high ($\bar{c} < \frac{(1-\alpha)\beta}{\alpha\gamma}$) to rule out uninteresting scenarios in which the entrepreneur never wants to implement the new product even with the most favorable market conditions. In addition, this assumption is also sufficient to guarantee the uniqueness of equilibrium.[4] In this paper, we consider two regimes: a non-disclosure regime in which the cost is not disclosed to the public, and a mandatory-disclosure regime in which the entrepreneur is required to disclose her implementation cost in the beginning.[5]

There is a continuum of consumers, indexed by $i \in [0, 1]$, who are potentially interested in the new product. Each consumer i is either an H-type with $\theta_i = \theta > 0$ or an L-type with $\theta_i = 0$, and he can only observe his own type. The type θ_i can be thought of as individual taste about the new product: H-type consumers love the product while L-type

[3] The following example illustrates how a typical crowdfunding project works. In 2013, SkyBell launched their funding campaign on Indiegogo for their smart video doorbells, and raised about $600,000 in 30 days. Observing the overwhelming demand, SkyBell later started mass production and began to sell its products on Amazon, BestBuy and other traditional retail stores. Andrew Thomas, the founder of SkyBell, stated the importance of crowdfunding for learning market demands: "When you can raise almost $600,000 in 30 days for a product that does not yet exist . . . It was clear that consumers wanted a video doorbell. Voting with one's money is the strongest validation there is" (Thomas 2017).

[4] If $\overline{c}$ is too high, there may exist an "unrealistic" equilibrium in which the entrepreneur implements the product only when the implementation cost is sufficiently high. This equilibrium, however, can be easily eliminated by common refinements such as Pareto dominance and equilibrium stability.

[5] For instance, in the offering statement filed to the SEC, Moonlighting LLC discloses that, to launch its new product (an online freelancing platform), it will need $214,000 on research and development, $267,500 on future wages, and $223,095 on general working capital, etc. See page 18 at https://www.sec.gov/Archives/edgar/data/1745226/000174522618000005/formc.pdf.

consumers show no interest in the product. We denote the proportion of H-type consumers to be $\tilde{q}$, i.e., $\tilde{q} = \Pr(\theta_i = \theta)$, and we often refer to it as "the market taste." The proportion of H-type consumers is unknown to all parties *ex ante*, but they all share a common prior that it follows a uniform distribution in the unit interval, i.e., $\tilde{q} \sim U\ [0,1]$.

Crowdfunding usually provides valuable market feedback to entrepreneurs, which is an important benefit for entrepreneurs to test their business ideas in the crowdfunding market first. Based on fund-raising/pre-ordering in crowdfunding markets, entrepreneurs are able to learn more about the market taste for their innovations. To capture the feedback role of crowdfunding in a parsimonious way, we assume that, before deciding whether to launch the new product, the entrepreneur first approaches a crowdfunding market which is composed of a randomized subsample of all consumers. For our convenience, we refer to this subset of potential consumers as "crowdfunding consumers." We assume the crowdfunding consumers make up $1-\beta$ proportion of all consumers, with $\beta \in (0,1)$. The remaining β proportion of potential consumers are assumed to be consumers in the traditional mass market, and we refer to them as "traditional consumers."

Once approached by the entrepreneur, each crowdfunding consumer, given his type θ_i, decides how many units of the new product to pre-order at date 0, denoted by x_i^C. Each crowdfunding consumer provides Px_i^C to the entrepreneur for his pre-order, where P is the unit price the entrepreneur asks. The aggregate order from the crowdfunding market is denoted by $X^C = \int_0^{1-\beta} x_i^C di$. Each crowdfunding consumer's utility is

$$U^C(\theta_i, x_i^C) = k(\theta_i - P)x_i^C - \frac{\gamma}{2}\left(Px_i^C\right)^2, \tag{1}$$

where $k \in \{0,1\}$ is the entrepreneur's subsequent implementation decision: $k=1$ represents the entrepreneur's decision to launch/implement the new product, while $k=0$ stands that the entrepreneur gives up launching the new product. If the entrepreneur decides to launch the new product, the crowdfunding consumer will receive x_i^C units products that

he pre-ordered, which provide him with a utility of $\theta_i x_i^C$. If the entrepreneur later gives up launching the new product, the crowdfunding consumer will get back his initial payment/contribution, Px_i^C, from the entrepreneur. However, regardless of the entrepreneur's implementation decision, the crowdfunding consumer always incurs a cost of $\frac{\gamma}{2}\left(Px_i^C\right)^2$, which can be interpreted as costs of raising capital or opportunity costs of sacrificing current consumptions. We further assume the unit price of the new product reflects a sharing of the utility brought by the new product between the consumer and the entrepreneur. As each unit of the new product brings utility θ_i to the consumer, the entrepreneur asks for a proportion $\alpha \in (0,1)$ of θ_i as the unit price. That is, $P = \alpha\theta_i$.[6]

At date 1, after observing the total pre-orders from the crowdfunding market, the entrepreneur decides whether to launch the new product. If she decides to launch the product, she incurs the implementation cost c; otherwise, she returns the contribution Px_i^C to the crowdfunding consumers, and the game ends.

At date 2, if the entrepreneur has decided to launch the new product, she delivers the product to crowdfunding consumers who have pre-ordered and also sells the new product in the traditional market. We denote each traditional consumer's order amount by x_i^T, and the total order from the traditional market is thus $X^T = \int_{1-\beta}^{1} x_i^T di$. Each traditional consumer's utility is

$$U^T(\theta_i, x_i^T) = (\theta_i - P)\, x_i^T - \frac{\gamma}{2}\left(Px_i^T\right)^2. \tag{2}$$

The utility function of a traditional consumer is the same as that of a crowdfunding consumer except that, the traditional consumer faces no uncertainty regarding the product launch when he places the order, as the entrepreneur has already decided to produce ($k = 1$).

Finally, the entrepreneur's payoff is equal to 0 if she decides not to launch the product. If she launches the product, her payoff is equal to the sum of profits from the crowdfunding

[6] Although this is a simplifying assumption regarding the price, it can be justified by a Nash bargaining game. We include in the appendix a simple model to illustrate the Nash bargaining analysis and show that $P = \alpha\theta_i$ is consistent with the equilibrium result in a Nash bargaining game.

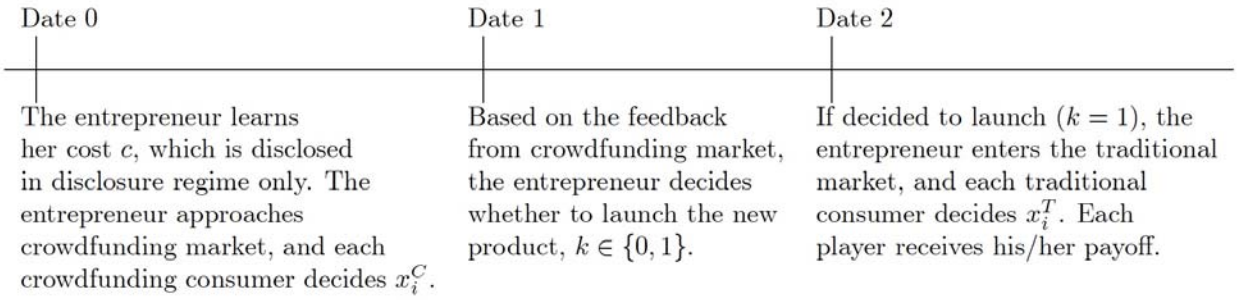

Figure 1: Time line.

and the traditional markets minus the implementation cost, i.e.,

$$V(k) = k\left(PX^C + PX^T - c\right). \tag{3}$$

The time line of the game is summarized in Figure 1.

4 Analysis

We now analyze the role of disclosure in the presence of a crowdfunding market besides the traditional market. We start with a complete-information benchmark in which consumers and the entrepreneur have complete information about the implementation cost c and the realization of market taste q. We then examine a non-disclosure regime in which the entrepreneur's implementation cost is not disclosed to the public, and a mandatory-disclosure regime in which the entrepreneur is mandated to disclose her implementation cost information.

4.1 Benchmark: Complete Information

We denote x_o^C as the equilibrium pre-order for H-type crowdfunding consumers, and x_o^T as the equilibrium order for H-type traditional consumers. We characterize the equilibrium in

the following proposition.

Proposition 1 *In the complete-information benchmark,*

- *the L-type consumers never order;*
- *there exists a threshold q^o, such that each H-type consumer orders $x_o^C = x_o^T = \frac{1-\alpha}{\alpha^2\gamma\theta}$ and the entrepreneur launches the new product ($k = 1$) if and only if $q > q^o$; otherwise, no consumer orders and the entrepreneur does not launch ($k = 0$).*

Proof. All proofs are in the appendix. ■

It is obvious that the L-type consumers never order, as they gain no utility from the new product. For an H-type crowdfunding consumer, he pre-orders $x_o^C = \frac{1-\alpha}{\alpha^2\gamma\theta}$ only when he anticipates that the entrepreneur will launch the new product ($k = 1$). Such anticipation is perfect because each consumer, thanks to the complete information, can step into the entrepreneur's shoes and gauge whether her expected profit exceeds the implementation cost. Furthermore, because there is no uncertainty regarding the entrepreneur's launching decision, crowdfunding consumers' decisions are the same as traditional consumers': both will order $x_o^C = x_o^T = \frac{1-\alpha}{\alpha^2\gamma\theta}$ if $k = 1$.

Given the equilibrium order of each crowdfunding and traditional consumer, the entrepreneur's implementation decision becomes straightforward. Since the entrepreneur has directly observed the market taste, the total pre-orders from the crowdfunding market, X_o^C, contain no new information, and thus crowdfunding does not provide feedback to the entrepreneur. That is, she launches the new product ($k = 1$) if and only if the observed market taste is favorable enough. To see this, note that the net benefit of launching the new product is the total profits from the two markets, minus the implementation cost for

the entrepreneur,

$$\underbrace{P[x_o^C(1-\beta)q]}_{\text{profit from the crowdfunding market}} + \underbrace{P[x_o^T\beta q]}_{\text{expected profit from the traditional market}} - \underbrace{c,}_{\text{the implementation cost}} \tag{4}$$

which is strictly increasing in q. Thus, the entrepreneur will follow a threshold strategy q^o. Moreover, it is easy to see that the threshold is increasing in the implementation cost c.

4.2 Non-disclosure Regime

We now turn to our main setting in which the market taste q is not observable to any party, and the entrepreneur's implementation cost c is her private information. We first consider the non-disclosure regime in which c is not revealed to consumers. We solve the model by backward induction and start with the traditional consumers' decision at date 2. The traditional consumers' decisions are moot if the entrepreneur has decided not to launch the new product. Otherwise, if the entrepreneur has decided to implement the new product ($k = 1$), each H-type traditional consumer chooses x_i^T to maximize his expected payoff,

$$U^T(\theta, x_i^T) = (\theta - \alpha\theta)\, x_i^T - \frac{\gamma}{2}\left(\alpha\theta x_i^T\right)^2.$$

Taking the first-order condition gives the equilibrium order choice for the H-type traditional consumer, denoted by x_{nd}^T (where nd stands for non-disclosure):

$$x_{nd}^T = \frac{1-\alpha}{\alpha^2\gamma\theta}. \tag{5}$$

Note that the traditional consumers' orders are identical with those in the complete-information benchmark, i.e., $x_{nd}^T = x_o^T$. This is because the information on the implementation cost c and the market taste q is useful only in inferring the entrepreneur's implementation decision k. Since the traditional consumers place their orders after observing k,

the information on c and q, or lack thereof, will not alter their orders.

Back to date 1, the entrepreneur decides on whether to launch the new product by comparing the implementation cost c with the expected total profits. She will choose to launch the new product ($k = 1$) if and only if the profits outweigh the cost:

$$P\left[X_{nd}^{C} + X_{nd}^{T}(q)\right] = \alpha\theta\left[X_{nd}^{C} + X_{nd}^{T}(q)\right] \geq c, \tag{6}$$

where $X_{nd}^{T}(q) \equiv \int_{1-\beta}^{1} x_{ndi}^{T} di$ denotes the equilibrium total purchase from the traditional market. The entrepreneur observes the pre-orders from the crowdfunding market, X_{nd}^{C}, at date 1 as she has received them. However, she must conjecture the future orders from the traditional market $X_{nd}^{T}(q)$, which, in turn, depend on the market taste q.

Although the market taste q is unobservable, the entrepreneur is able to learn the market taste through the crowdfunding market. Indeed, the entrepreneur rationally anticipates that each crowdfunding consumer takes into account his own taste in submitting the pre-order. When aggregated, these pre-orders reflect how favorable the market taste is. Specifically, in order to learn from crowds, the entrepreneur must conjecture the crowdfunding consumers' ordering decisions. Since the L-type consumers never order, the entrepreneur conjectures that each H-type consumer orders $\hat{x}_{nd}^{C}$. Given that conjecture, the entrepreneur rationally anticipates that, for any level of market taste q, the total pre-orders should be

$$\hat{X}_{nd}^{C}(q) = \int_{0}^{1-\beta} \hat{x}_{nd}^{C} di = (1-\beta)\,\hat{x}_{nd}^{C} q. \tag{7}$$

Equating the conjectured total order $\hat{X}_{nd}^{C}(q)$ with the actual order X^{C} allows the entrepreneur to infer the level of market taste. The entrepreneur's inference of q, denoted by $\hat{q}$, is given by:

$$\hat{q}\left(X^{C}\right) = \frac{X^{C}}{(1-\beta)\,\hat{x}_{nd}^{C}}. \tag{8}$$

Learning from crowds plays a vital role in the entrepreneur's implementation decision

(as governed by (6)). By plugging the inferred market taste $\hat{q}$ into the equilibrium total orders from the traditional market X_{nd}^T, the entrepreneur is now able to forecast the future profits from the traditional market, and launches the product when

$$\alpha\theta\left[X^C + X_{nd}^T\left(\hat{q}\left(X^C\right)\right)\right] \geq c. \tag{9}$$

Note that the LHS is strictly increasing in X^C. The entrepreneur thus launches the new product if and only if the pre-orders from the crowdfunding market are above the threshold, $\bar{X}_{nd}^C(c)$, which is a function of the implementation cost c:

$$\bar{X}_{nd}^C(c) = \frac{c}{\alpha\theta\left(1 + \frac{\beta}{(1-\beta)\hat{x}_{nd}^C}\frac{1-\alpha}{\alpha^2\gamma\theta}\right)}. \tag{10}$$

The higher the implementation cost, the greater the crowdfunding pre-orders that the entrepreneur needs to launch the product.

Back to date 0, each H-type crowdfunding consumer decides on his order x_i^C to maximize

$$E[U^C(\theta, x_i^C)] = E(k)(\theta - \alpha\theta)x_i^C - \frac{\gamma}{2}\left(\alpha\theta x_i^C\right)^2. \tag{11}$$

Compared with the complete-information benchmark, the lack of information on the implementation cost c and the market taste q alter the the crowdfunding consumers' pre-orders. To see this, notice that the equilibrium order choice, denoted by x_{nd}^C, satisfies

$$x_{nd}^C = \frac{(1-\alpha)E(k)}{\alpha^2\gamma\theta}. \tag{12}$$

In contrast to the traditional consumers, the crowdfunding consumers must infer the expected implementation decision $E(k)$ since they place their orders before the entrepreneur decides whether to launch the new product. Each crowdfunding consumer infers $E(k)$ by rationally anticipating the entrepreneur's learning from the crowds: the entrepreneur will

choose $k = 1$ if and only if the total orders from the crowdfunding market is sufficiently high, i.e., $X_{nd}^C \geq \bar{X}_{nd}^C\left(\hat{x}_{nd}^C, c\right)$.

Importantly, two types of uncertainty get in the way when the crowdfunding consumers infer the entrepreneur's decision k. First, there is *fundamental uncertainty* regarding the implementation cost c. Since c is not disclosed and is unknown to the crowdfunding consumers, each crowdfunding consumer can only rely on his prior belief about c to infer the chance of future implementation.

Second, since the entrepreneur learns from crowds and her implementation decision is contingent on the total pre-orders from the crowdfunding market, the crowdfunding consumers must conjecture each other's pre-order decisions in the course of inferring k. In this light, learning by the entrepreneur leads to *strategic uncertainty* for each crowdfunding consumer, who must coordinate his pre-order with others. Formally, note that $\dfrac{\partial E(k)}{\partial X_{nd}^C} > 0$, that is, crowdfunding consumers anticipate that the entrepreneur is more likely to launch the new product if the aggregate order X_{nd}^C is larger. Furthermore, from (12), each crowdfunding consumer's pre-order amount x_{nd}^C is increasing in $E(k)$. Collectively,

$$\frac{\partial x_{nd}^C}{\partial X_{nd}^C} = \frac{\partial x_{nd}^C}{\partial E(k)} \frac{\partial E(k)}{\partial X_{nd}^C} > 0, \tag{13}$$

which means the crowdfunding consumers' pre-orders are strategic complements. Moreover, the lack of information on the market taste q further heightens the strategic uncertainty. To see this, recall that from equation (7), the equilibrium total orders from the crowdfunding market $X_{nd}^C(q)$ depend on q. With q unknown, each crowdfunding consumer infers $X_{nd}^C(q)$ only based on his prior belief about q.

In sum, taking into account the fundamental uncertainty regarding c and the strategic uncertainty stemming from unknown q, crowdfunding consumers' inference of the imple-

mentation decision can be written as:

$$E(k) = E_{\{c,q\}}\left[\Pr\left(\hat{X}_{nd}^{C}(q) \geq \bar{X}_{nd}^{C}(c)\right)\right], \tag{14}$$

where $E_{\{c,q\}}[\cdot]$ represents the conjecture taking expectations over both c and q.

We summarize the full equilibrium of the non-disclosure regime in the following proposition.

Proposition 2 *In the non-disclosure regime,*

- *the L-type consumers never order;*
- *each H-type crowdfunding consumer pre-orders* $x_{nd}^{C} = \dfrac{(1-\alpha)E(k)}{\alpha^2\gamma\theta} < x_o^C$;
- *there exists a threshold* $q^{nd} \geq q^o$*, such that the entrepreneur launches the new product* ($k = 1$) *if and only if* $q > q^{nd}$*. Upon implementation* ($k = 1$)*, each H-type traditional consumer orders* $x_{nd}^{T} = \dfrac{1-\alpha}{\alpha^2\gamma\theta} = x_o^T$.

Proposition 2 highlights some important consequences when the crowdfunding market receives no information on the implementation cost c nor the market taste q. First, the crowdfunding consumers place smaller pre-orders than in the complete-information benchmark, i.e., $x_{nd}^{C} < x_o^C$. Second, the smaller pre-orders have real effects and can preempt the entrepreneur from launching the new product. To illustrate, we plot in Figure 2 the entrepreneur's decisions in the non-disclosure regime and the complete-information benchmark. Figure 2 shows that, under either extremely unfavorable or favorable market conditions (i.e., q close to either 0 or 1), the entrepreneur's implementation decision in the non-disclosure regime coincides with that in the complete-information benchmark. Thus the loss of information entails no implementation inefficiency. Nonetheless, the under-implementation inefficiency arises when the market taste is moderate (i.e., $q \in \left[q^o, q^{nd}\right]$): in the complete-information benchmark the entrepreneur launches the new product, while

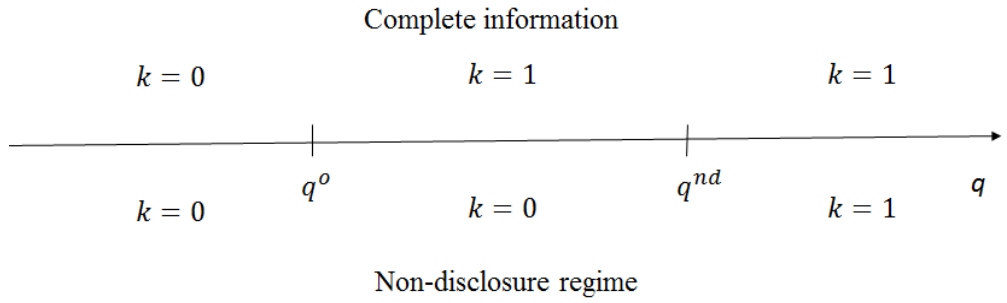

Figure 2: The implementation decision in the benchmark versus in the non-disclosure regime.

in the non-disclosure regime she chooses not to. In sum, *ex ante*, the entrepreneur under-implements in the non-disclosure regime.

We summarize this implementation inefficiency result in the following proposition.

Proposition 3 *In the non-disclosure regime, the entrepreneur under-implements compared with the complete-information benchmark.*

The intuition for Proposition 3 is as follows. Recall that, due to the feedback role of crowdfunding, the entrepreneur's implementation decision is driven by the crowdfunding consumers' pre-orders. The stronger the demand in the crowdfunding market, the more likely the entrepreneur launches the new product. Yet, an examination of equation (12) shows that the crowdfunding market demand is weaker than in the complete-information benchmark:

$$x_{nd}^{C} = \frac{(1-\alpha)\, E_{\{c,q\}}\left[\Pr\left(\hat{X}_{nd}^{C}(q) \geq \bar{X}_{nd}^{C}(c)\right)\right]}{\alpha^2\gamma\theta} < \frac{1-\alpha}{\alpha^2\gamma\theta} = x_{o}^{C}. \tag{15}$$

The inequality is driven by $E_{\{c,q\}}\left[\Pr\left(\hat{X}_{nd}^{C}(q) \geq \bar{X}_{nd}^{C}(c)\right)\right] < 1$. Intuitively, the lack of information in the non-disclosure regime hinders crowdfunding consumers from participating, leading to under-implementation by the entrepreneur.

In summary, our analysis of the non-disclosure regime suggests that, the crowdfunding

market brings both a benefit and a downside on the entrepreneur's implementation decision. On the one hand, the crowdfunding market provides the entrepreneur with a channel to learn about the market taste, which helps the entrepreneur make a more informed implementation decision. On the other hand, there also exists a downward distortion in the crowdfunding consumers' pre-orders, which, in turn, induce the entrepreneur to under-implement. This downward distortion in pre-orders is driven by both the fundamental uncertainty regarding the implementation cost and the strategic uncertainty in the crowdfunding market.

Given both the learning benefit and the under-implementation inefficiency of the crowdfunding market, one may wonder whether there are ways to mitigate the under-implementation distortion. As under-implementation is partially caused by the fundamental uncertainty regarding the implementation cost, one may suggest that disclosing the implementation cost could eliminate this uncertainty and thus alleviate the under-implementation inefficiency. In fact, the SEC has mandated a number of disclosure requirements in the hope of promoting transparency and protecting investors in the crowdfunding market. In the following section, we will examine such a setting in which the implementation cost is required to disclosed to the market.

4.3 Mandatory-disclosure Regime

In the disclosure regime, the equilibrium decisions of the traditional consumers, denoted by x^T_{md} (where md stands for mandatory-disclosure), remains the same as in the non-disclosure regime, $x^T_{md} = x^T_{nd}$. This is because with the implementation already in place, the disclosure of the implementation cost *per se* does not play any role in the traditional consumers' decision. The entrepreneur's optimal implementation decision is also similar to that in the non-disclosure regime: she chooses $k = 1$ if and only if the total crowdfunding market demands are above a threshold, $X^C \geq \bar{X}^C_{md}(c)$.

However, the pre-order decision by the crowdfunding consumers, denoted by x^C_{md}, is now affected by the information of the implementation cost. In particular, conditional

on the disclosure of c, the H-type crowdfunding consumers update their inferences of the implementation decision to be

$$E(k|c) = E_q\left[\Pr\left(\hat{X}^C_{md}(q) \geq \bar{X}^C_{md}(c)\right)\right]. \tag{16}$$

Note that, while the disclosure has eliminated the fundamental uncertainty regarding c, the crowdfunding consumers still face the strategic uncertainty and need to conjecture about the market taste q. Moreover, $E(k|c)$ is decreasing in the implementation cost c. The intuition is as follows: since the implementation threshold $\bar{X}^C_{md}(c)$ is increasing in c, observing a higher implementation cost lowers the crowdfunding consumers' expectation of the implementation chance.

The following proposition summarizes the full equilibrium of the mandatory-disclosure regime.

Proposition 4 *In the mandatory-disclosure regime,*

1. *L-type consumers never order;*
2. *each H-type crowdfunding consumer pre-orders* $x^C_{md} = \dfrac{(1-\alpha)E(k|c)}{\alpha^2\gamma\theta} < x^C_o$;
3. *there exists a threshold* $q^{md} \geq q^o$, *such that the entrepreneur launches the new product* ($k=1$) *if and only if* $q > q^{md}$. *Upon implementation* ($k=1$), *each H-type traditional consumer orders* $x^T_{md} = \dfrac{1-\alpha}{\alpha^2\gamma\theta} = x^T_o$.

Proposition 4 indicates that the crowdfunding consumer's pre-order decision in the mandatory-disclosure regime still shows a downward distortion from that in the complete-information benchmark, i.e., $x^C_{md} < x^C_o$. Although now the crowdfunding consumers observe the implementation cost and thus can better infer the implementation decision, the strategic uncertainty still exists, as each crowdfunding consumer remains uncertain about other crowdfunding consumers' tastes. That strategic uncertainty continues to deter crowdfunding consumers from participating, which in turn weakens the entrepreneur's incentive to

launch the new product. Therefore, we still obtain under-implementation even with the mandatory disclosure of c.

Proposition 5 *In the mandatory-disclosure regime, the entrepreneur still under-implements compared with the complete-information benchmark.*

4.4 The Effect of Disclosure on Under-implementation

We have shown that, even if the implementation cost is mandated to be disclosed, the under-implementation inefficiency still exists. Nevertheless, one may conjecture that the mandatory disclosure should at least alleviate the under-implementation, as the disclosure resolves the information asymmetry regarding the implementation cost. In this section, we aim to examine whether such a conjecture is true by comparing the entrepreneur's implementation decisions in the two regimes.

We first make an *ex-post* comparison conditional on the realization of c, from which we can better understand the role of disclosure for specific projects. We find that the effect of disclosure depends on the level of implementation cost that is disclosed. The mandatory disclosure of c helps to mitigate the under-implementation inefficiency only when the cost c is sufficiently low, while when c is sufficiently high, it actually makes the under-implementation even worse.

Proposition 6 *Given the implementation cost c, mandatory disclosure mitigates the under-implementation if $c \leq c^*$, but aggravates the under-implementation if $c > c^*$.*

The key intuition behind Proposition 6 is that disclosure not only reduces the information asymmetry, but also affects the strategic uncertainty for the crowdfunding consumers and alters the coordination among them. Specifically, if the implementation cost is low, disclosing that information improves the coordination among crowdfunding consumers. To see this, when a low implementation cost is revealed, crowdfunding consumers anticipate a

greater chance that the new product will be launched, and thus are willing to pre-order more since their choices are strategic complements. As crowdfunding consumers are coordinated towards participating more actively, the stronger aggregate pre-orders conveys a more favorable feedback to the entrepreneur and makes her lean towards launching the product, which further attracts crowdfunding consumers to participate more actively. That is, the disclosure of a low implementation cost helps the crowdfunding consumers to coordinate on an equilibrium in which the demand in the crowdfunding market is strong and the entrepreneur is highly likely to launch the new product, resulting in less severe under-implementation than in the non-disclosure regime.

In contrast, if the implementation cost is high, disclosure aggravates the coordination problem. A high implementation cost generates a serious concern that the entrepreneur might not launch the product. The anticipated high risk of no implementation coordinates consumers to stay away from participating in the crowdfunding. The weak demand from the crowdfunding market, in turn, makes the entrepreneur more pessimistic about the prospect of her new product, which makes the already costly implementation even more unlikely. Eventually, the interaction between the crowdfunding market and the entrepreneur leads to an equilibrium with a weak crowdfunding market demand and a low likelihood of implementation. As a result, disclosure makes the under-implementation problem even worse.

Given different implementation costs, we have shown that the disclosure of c may alleviate or aggravate the under-implementation problem. One may wonder, *ex ante*, whether the mandatory disclosure of c helps to mitigate the under-implementation inefficiency. Examining the *ex-ante* effect of disclosure is relevant for generating policy implications because, in practice, regulators often contemplate on making disclosure mandates for the entire crowdfunding market instead of specific projects. Towards this end, we make an *ex-ante* comparison between the entrepreneur's implementation decisions with and without mandatory disclosure, taking into account all possible levels of implementation cost. Our analysis shows

a somewhat surprising result that, *ex ante*, the mandatory disclosure always aggravates the under-implementation inefficiency.

Proposition 7 *Ex ante, the mandatory disclosure always aggravates the under-implementation.*

The result in Proposition 7 is driven by an asymmetry in the coordination effects of disclosure on under-implementation when the implementation cost is low versus when the cost is high. By Proposition 6, mandatory disclosure mitigates the under-implementation if the implementation cost c is low, but aggravates the under-implementation if c is high. Nonetheless, the benefit of disclosing a low c is asymmetrically smaller than the cost of disclosing a high c. To see this, consider first one extreme case in which c is low and close to 0. In this case, the entrepreneur will launch the new product even without a strongly favorable feedback from the crowds, thanks to the minimal implementation cost. Although disclosure still marginally mitigates the crowdfunding consumers' inadequate pre-orders, it yields almost no benefit to the entrepreneur's implementation decision. Now consider the other extreme case in which c is high and close to its upper bound $\bar{c}$. Facing a high implementation hurdle, the entrepreneur is keen on the feedback from the crowdfunding market to gauge whether to launch the product. In fact, she will not launch the product unless receiving overwhelmingly strong crowdfunding demands. In other words, the detrimental effect of disclosing a high cost on the implementation efficiency is quite substantial. Because of the asymmetry, *ex ante*, mandatory disclosure always aggravates the entrepreneur's under-implementation problem.

Proposition 7 sends a message of caution against the recent regulatory changes towards more disclosure in the crowdfunding market. To a large extent, such regulatory changes are motivated by the idea that disclosure helps to reduce information asymmetry and thus enhances market transparency, and the greater transparency in turn encourages participations in crowdfunding markets and helps to stimulate innovations. However, on the contrary to this common belief, our analysis finds the opposite: while more disclosure indeed brings

more information to the market, it could actually deter crowdfunding and hinder innovation. The key takeaway is that disclosure may heighten the strategic uncertainty faced by crowdfunding consumers, and therefore its overall effect may be detrimental.

5 Conclusion

In the internet era, crowdfunding offers a new avenue for entrepreneurs to raise funds from a broader set of investors who usually do not invest in traditional financial markets. Entrepreneurs manage to attract these investors' interests by promising them a new product once crowdfunding campaigns succeed. In other words, crowdfunding helps entrepreneurs to turn potential consumers into investors. We show that financing from consumers yields an additional benefit compared to conventional financing channels: it not only brings entrepreneurs funds that are necessary for working on their new ideas, but, more importantly, allows consumers to vote on the ideas with their own money, thus providing credible feedback to entrepreneurs on how good the ideas are.

Given the importance of crowdfunding, regulators who usually focus on safeguarding traditional financial markets have extended their reach to the new crowdfunding market. Recently, the SEC has mandated a substantial set of disclosure requirements in the hope of promoting transparency and protecting investors. Yet, such mandatory disclosure is not without controversy and often criticized on the grounds that it imposes a high cost on small businesses.[7] We argue that even if one ignores the exogenous cost of fulfilling the disclosure requirement, the disclosure comes with an endogenous cost. We show that mandating greater disclosure interferes with the feedback role of crowdfunding and may even cause

[7] For instance, a comment letter to SEC by Kiran Lingam, the general counsel of SeedInvest, states that "we believe one of the biggest hurdles to making crowdfunding a viable option for small businesses is the cost and time burden... In the Proposed Rules, the Commission estimates that it will cost $6,000 (15 hours) in outside advisor costs and an additional 45 hours of internal team costs time to prepare the initial Offering Statement. Furthermore, the Commission believes it will cost $14,350 for reviewed financials and $28,700 for audited financials in outside advisor costs." See https://www.seedinvest.com/blog/jobs-act/sec-comment-letter-startups-shouldnt-gamble-crowdfunding.

entrepreneurs to give up new products that would have been launched absent the mandatory disclosure. In some sense, the disclosure requirement fails to protect crowdfunding investors to the extent that, even though investors become more informed about new products thanks to more disclosure, somewhat paradoxically, the disclosure also hinders the development of the products and prevents consumers from buying them.

References

[1] Agrawal, Ajay, Christian Catalini, and Avi Goldfarb. 2014. "Some Simple Economics of Crowdfunding." *Innovation Policy and the Economy* 14 (1): 63–97.

[2] Allen, Franklin, Stephen Morris, and Hyun Song Shin. "Beauty Contests and Iterated Expectations in Asset Markets." *The Review of Financial Studies* 19 (2006): 719-752.

[3] Angeletos, George-Marios, and Chen Lian. "Incomplete information in macroeconomics: Accommodating frictions in coordination." *Handbook of macroeconomics*. Vol. 2. Elsevier, 2016. 1065-1240.

[4] Belleflamme, Paul, Nessrine Omrani, and Martin Peitz. 2015. "The Economics of Crowdfunding Platforms." *Information Economics and Policy* 33: 11–28.

[5] Beyer, Anne, Cohen, Daniel. A., Lys, Thomas. Z., and Walther, Beverly. R. 2010. "The financial reporting environment: Review of the recent literature." *Journal of Accounting and Economics*, 50(2-3), 296-343.

[6] Chemla, Gilles, and Katrin Tinn. "Learning through crowdfunding." *Management Science*, forthcoming.

[7] Corona, Carlos, Lin Nan, and Gaoqing Zhang. "The Coordination Role of Stress Test Disclosure in Bank Risk Taking." Working paper, 2019. Available at SSRN: https://ssrn.com/abstract=3201973 or http://dx.doi.org/10.2139/ssrn.3201973.

[8] Gao, Pingyang. "Keynesian beauty contest, accounting disclosure, and market efficiency." *Journal of Accounting Research* 46.4 (2008): 785-807.

[9] Gao, Pingyang, and Xu Jiang. "Reporting choices in the shadow of bank runs." *Journal of Accounting and Economics* 65.1 (2018): 85-108.

[10] Kanodia, Chandra, and Haresh Sapra. "A real effects perspective to accounting measurement and disclosure: Implications and insights for future research." *Journal of Accounting Research* 54, no. 2 (2016): 623-676.

[11] Liang, Pierre Jinghong and Zhang, Gaoqing. "On the Social Value of Accounting Objectivity in Financial Stability." *The Accounting Review* (2019) 94:1, 229-248.

[12] Madsen, Joshua, and Jeff L. McMullin. "Economic Consequences of Risk and Ability Disclosures: Evidence from Crowdfunding." (2018).

[13] Mollick, Ethan. "The Dynamics of Crowdfunding: An Exploratory Study." *Journal of Business Venturing* 29.1 (2014): 1-16.

[14] Strausz, Roland. "A theory of crowdfunding: A mechanism design approach with demand uncertainty and moral hazard." *American Economic Review* 107, no. 6 (2017): 1430-76.

[15] Thomas, Andrew. "From zero to $600,000 in 30 days: a brilliant way to start your business." Available at https://www.inc.com/andrew-thomas/from-zero-to-600000-in-30-days-a-brilliant-way-to-start-your-business.html

[16] Xu, Ting. "Learning from the crowd: The feedback value of crowdfunding." *Available at SSRN 2637699* (2018).

[17] Zhang, Gaoqing. "Competition and Opacity in the Financial System: An Equilibrium Analysis with Rollover Risk." Working paper, October, 2018.

Appendix I: Proofs

Proof. of Proposition 1**:** Since a traditional consumer purchases the product after k is determined, his optimal purchase becomes.

$$\begin{aligned} \underset{x_i^T}{Max} \quad (\theta_i - P)\, x_i^T - \frac{\gamma}{2}(Px_i^T)^2 \text{ when } k &= 1; \\ \underset{x_i^T}{Max} \quad -\frac{\gamma}{2}(Px_i^T)^2 \text{ when } k &= 0. \end{aligned}$$

Therefore, when $k = 1$, he will purchase $x_o^T = \dfrac{\theta - P}{\gamma P^2} = \dfrac{1-\alpha}{\alpha^2\gamma\theta}$ for an H-type; or purchase 0 units for an L-type. Otherwise, when $k = 0$, his purchase becomes 0 regardless of the type.

For a crowdfunding consumer, we conjecture that he can perfectly anticipate the entrepreneur's implementation decision k, given q and c are observable. Later we will verify this conjecture. Given the perfect anticipation, each consumer's decision becomes

$$\underset{x_i^C}{Max} \quad k\,(\theta_i - P)\, x_i^C - \frac{\gamma}{2}(Px_i^C)^2.$$

Similarly, if he *anticipates* $k = 0$, he does not pre-order from the crowdfunding market; otherwise, if he *anticipates* $k = 1$, he will pre-order $x_o^C = \dfrac{1-\alpha}{\alpha^2\gamma\theta}$ for an H-type, or choose not to pre-order for an L-type.

Now we look at the entrepreneur's implementation decision k. The pre-orders from the crowdfunding market, $X_o^C = \displaystyle\int_0^\beta x_o^C di = (1-\beta)x_o^C q$, is realized, and the entrepreneur rationally anticipates traditional consumers' purchase, $\hat{X}_o^T = \displaystyle\int_{1-\beta}^1 x_o^T di = \beta x_o^T q$. Therefore, the expected profit (net cost) of implementing the new product is

$$PX_o^C + P\hat{X}_o^T - c = \frac{1-\alpha}{\alpha\gamma}q - c.$$

In other words, because the entrepreneur directly observes q, she chooses $k = 1$ if and only if $\dfrac{1-\alpha}{\alpha\gamma}q - c > 0$. Meanwhile, since each crowdfunding consumer also observes q and c, he

can perfectly anticipates whether this condition is satisfied, thus confirming our previous conjecture.

Furthermore, since $\frac{1-\alpha}{\alpha\gamma}q - c$ is strictly increasing in q and strictly decreasing in c, the entrepreneur's decision is governed by a threshold strategy $q > q^o \equiv \min\{\frac{\alpha\gamma c}{1-\alpha}, 1\} = \frac{\alpha\gamma c}{1-\alpha}$. The last equation comes from the assumption that $c < \bar{c} < \frac{(1-\alpha)\beta}{\alpha\gamma}$. ■

Proof. of Proposition 2**:** As shown in the text, the entrepreneur can infer the market taste q and forecast the future profit from the aggregate pre-order X_{nd}^C. Therefore, we insert equation (5) and (12) in equation (6) and get the following

$$\frac{E(k)\,(1-\beta)\,(1-\alpha)}{\alpha\gamma}q + \frac{\beta\,(1-\alpha)}{\alpha\gamma}q - c \geq 0.$$

Denote $\lambda = \frac{\alpha\gamma}{1-\alpha}$ and thus the entrepreneur implements if and only if

$$\frac{1}{\lambda}[(1-\beta)\,E(k) + \beta)]q - c \geq 0. \tag{17}$$

Now anticipating the entrepreneur's implementation strategy, a crowdfunding consumer believes that the probability of implementation is

$$\begin{aligned} E(k) &= \Pr[\frac{1}{\lambda}((1-\beta)\,E(k) + \beta)q - c \geq 0] \\ &= \int_0^{\bar{c}}\int_0^1 \frac{1}{\bar{c}}\Pr[\frac{1}{\lambda}((1-\beta)\,E(k) + \beta)q - c \geq 0]dqdc \\ &= \frac{1}{\bar{c}}\int_0^{\bar{c}} \max\{1 - \frac{\lambda c}{(1-\beta)\,E(k) + \beta}, 0\}dc \\ &= \frac{1}{\bar{c}}\int_0^{\bar{c}} \left(1 - \frac{\lambda c}{(1-\beta)\,E(k) + \beta}\right)dc. \end{aligned} \tag{18}$$

The last equation holds because $c < \bar{c} < \frac{(1-\alpha)\beta}{\alpha\gamma} = \frac{\beta}{\lambda}$, which further suggests $\frac{\lambda c}{(1-\beta)\,E(k) + \beta} <$

$\frac{\lambda c}{\beta} < 1$. After some algebra, we can reduce (18) into:

$$(1-\beta)\left(E(k)\right)^2 + (2\beta - 1)E(k) - \beta + \frac{\lambda \bar{c}}{2} = 0.$$

Denote $E(k)$ by t and the LHS of the above equation by $f_1(t)$. Since t is a probability, we verify the function value at the two corners as follows:

$$\begin{aligned} f_1(1) &= \frac{\lambda \bar{c}}{2} > 0, \\ f_1(0) &= \frac{\lambda \bar{c}}{2} - \beta < 0. \end{aligned}$$

By the intermediate value theorem, there exists a solution t^* for $f_1(t) = 0$. In addition, since $f_1(t)$ is a quardratic function of t, t^* must be unique in the interval $[0, 1]$ as follows:

$$t^* = \frac{1 - 2\beta + \sqrt{1 - 2\lambda \bar{c}(1-\beta)}}{2(1-\beta)}.$$

Given the belief $E(k)$, each crowdfunding consumer will invest $x_{nd}^C = \frac{t^*(1-\alpha)}{\alpha^2 \gamma \theta}$ in equilibrium. After pluging the equilibrium t^* in equation (17), the entrepreneur chooses $k = 1$ if and only if

$$q > \frac{\lambda c}{(1-\beta)t^* + \beta} = \frac{2\lambda c}{1 + \sqrt{1 - 2\lambda \bar{c}(1-\beta)}}.$$

In other words, the entrepreneur's implementation decision is governed by a unique threshold:

$$q^{nd} = \frac{2\lambda c}{1 + \sqrt{1 - 2\lambda \bar{c}(1-\beta)}}. \tag{19}$$

■

Proof. of Proposition 3**:** By the proof of Proposition 1 and Proposition 2, we have

$$\begin{aligned} q^{nd} &> q^{o} \Leftrightarrow \frac{2\lambda c}{1+\sqrt{1-2\lambda\bar{c}(1-\beta)}} > \lambda c \\ &\Leftrightarrow 1 > \sqrt{1-2\lambda\bar{c}(1-\beta)}, \end{aligned}$$

which is always satisfied. ■

Proof. of Proposition 4**:** We conjecture that a crowdfunding consumer can perfectly anticipate the entrepreneur's implementation strategy q^{md} due to the disclosure of c. Given this conjecture, each consumer calculates the expected probability of implementation as

$$E(k|c) = \Pr(q > q^{md}) = 1 - q^{md}.$$

Therefore, his optimal pre-order becomes

$$x_{md}^{C} = \frac{(1-\alpha)\,E(k|c)}{\alpha^2\gamma\theta} = \frac{(1-\alpha)\,(1-q^{md})}{\alpha^2\gamma\theta}.$$

Similar to the non-disclosure regime, given the crowdfunding consumer's strategy x_{md}^{C}, the aggregate pre-orders X_{md}^{C} reveals the market condition to the entrepreneur, which, in turn, allows the entrepreneur to forecast future orders $\hat{X}_{md}^{T}$. As a result, the entrepreneur implements the project if and only if

$$\alpha\theta\left[X_{md}^{C} + \hat{X}_{md}^{T}\right] \geq c \Leftrightarrow \frac{1}{\lambda}\left[(1-\beta)\left(1-q^{md}\right)q + \beta q\right] - c > 0.$$

By rational expectation, when $q = q^{md}$, the entrepreneur is indifferent between implementation and non-implementation, i.e.,

$$\frac{1}{\lambda}\left[(1-\beta)\left(1-q^{md}\right)q^{md} + \beta q^{md}\right] - c = 0. \tag{20}$$

Denote q^{md} by t and the above equation by $f_2(t)$. We have

$$\begin{aligned} f_2(0) &= -c < 0, \\ f_2(1) &= \frac{\beta}{\lambda} - c > \frac{\beta}{\lambda} - \bar{c} > 0. \end{aligned}$$

Similar to the proof of Proposition 2**,** there exists a unique solution t^* for $f_2(t) = 0$ in the interval $[0, 1]$ such that:

$$t^* = \frac{1 - \sqrt{1 - 4\lambda c(1-\beta)}}{2(1-\beta)}.$$

Finally, since q^{md} is a function of λ, c and β, the crowdfunding consumer is able to anticipate its value at date 0, thus confirming our previous conjecture. ■

Proof. of Proposition 5**:** First, we rewrite q^{md} as follows

$$q^{md} = \frac{1 - \sqrt{1 - 4\lambda c(1-\beta)}}{2(1-\beta)} = \frac{2\lambda c}{1 + \sqrt{1 - 4\lambda c(1-\beta)}}.$$

Therefore, $q^{md} > q^o$ is equivalent to

$$\begin{aligned} q^{md} &> q^o \Leftrightarrow \frac{2\lambda c}{1 + \sqrt{1 - 4\lambda c(1-\beta)}} > \lambda c \\ &\Leftrightarrow 1 > \sqrt{1 - 4\lambda c(1-\beta)}, \end{aligned}$$

which is satisfied. ■

Proof. of Proposition 6**:** From the proof of Proposition 3 and 5,

$$q^{md} < q^{nd} \Leftrightarrow \frac{2\lambda c}{1 + \sqrt{1 - 4\lambda c(1-\beta)}} < \frac{2\lambda c}{1 + \sqrt{1 - 2\lambda \bar{c}(1-\beta)}} \Leftrightarrow c < \frac{\bar{c}}{2}.$$

■

Proof. of Proposition 7**:** Since q^{nd} and q^{md} are always interior, the *ex-ante* probability

of implementation is equal to

$$\begin{aligned} E[\Pr(k^{nd} &= 1)] = \frac{1}{\bar{c}}\int_0^{\bar{c}}\int_0^1 \Pr(q > q^{nd})dqdc = \frac{1}{\bar{c}}\int_0^{\bar{c}}(1-q^{nd})dc; \\ E[\Pr(k^{md} &= 1)] = \frac{1}{\bar{c}}\int_0^{\bar{c}}\int_0^1 \Pr(q > q^{md})dqdc = \frac{1}{\bar{c}}\int_0^{\bar{c}}(1-q^{md})dc. \end{aligned}$$

Now we write q^{nd} and q^{md} as a function of c, and we can easily show that

$$\begin{aligned} \frac{\partial q^{md}(c)}{\partial c} &= \frac{\lambda}{\sqrt{1-4\lambda c(1-\beta)}} > 0, \\ \frac{\partial^2 q^{md}(c)}{\partial c^2} &= \frac{2(1-\beta)\lambda^2}{[1-4\lambda c(1-\beta)]^{\frac{3}{2}}} > 0, \end{aligned}$$

suggesting that $q^{md}(c)$ is strictly increasing and convex in c. Therefore, by Jensen's inequality,

$$E[q^{md}(c)] > q^{md}\left(E\left[c\right]\right) = q^{md}\left(\frac{\bar{c}}{2}\right).$$

In addition, since $q^{nd}(c)$ is a linear function of c, we also have

$$E[q^{nd}(c)] = q^{nd}\left(E\left[c\right]\right) = q^{nd}\left(\frac{\bar{c}}{2}\right).$$

Finnaly, recall that the proof of Proposition 6 shows that $q^{md}(c) = q^{nd}(c)$ if and only if $c = \frac{\bar{c}}{2}$. This in turn suggests that $E[q^{md}(c)] > E[q^{nd}(c)]$. Therefore,

$$E[\Pr(k^{md} = 1)] = E[1 - q^{md}(c)] < E[1 - q^{nd}(c)] = E[\Pr(k^{nd} = 1)].$$

That is, the *ex ante* probability of implementing the product is higher in the non-disclosure regime. ■

Appendix II: Nash Bargaining Game for Price

In our main model we assume that the unit price to both crowdfunding and traditional markets is $P = \alpha\theta$. We now use a simple Nash bargaining game to give a microfoundation for this assumption.

If the entrepreneur chooses not to implement the new product, i.e., $k = 0$, the bargaining game collapses and price is irrelevant. Nevertheless, if the entrepreneur decides to implement the new product, i.e., $k = 1$, she negotiates the equilibrium price with consumers based on the expected payoffs, shown as follows:

	Consumer	Entrepreneur
Negotiation succeeds	$(\theta_i - P)\, x_i - \frac{\gamma}{2}\left(\hat{P}x_i\right)^2$	Px_i
Negotiation fails	$-\frac{\gamma}{2}\left(\hat{P}x_i\right)^2$	0

In particular, given the anticipated price per unit $\hat{P}$, each consumer incurs a cost of $\frac{\gamma}{2}\left(\hat{P}x_i\right)^2$ as the cost of raising capital. Obviously, an L-type consumer is never interested in the product, and thus we only need to consider the H-type. Note that, from a successful negotiation, the consumer receives a surplus of $(\theta - P)\, x_i$, whereas the entrepreneur receives a surplus of Px_i. So the total surplus is θx_i. Since the entrepreneur has a bargaining power of α, he should receive a fraction α of the total surplus:

$$Px_i = \alpha\theta x_i \Rightarrow P = \alpha\theta. \tag{21}$$

Finally, since crowdfunding and traditional consumers have the same bargaining power, the equilibrium price will be the same.