The Real Effects of Transparency in Crowdfunding

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Abstract

In this paper, we investigate the real effects of information transparency in crowdfunding markets. Our analysis identifies that crowdfunding provides a benefit for an entrepreneur to learn consumers' preferences before deciding whether to implement an innovative project. 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 greater transparency regarding the implementation cost, although diminishes the fundamental uncertainty, may not necessarily mitigate the strategic uncertainty. We obtain a somewhat surprising result that, from an *ex ante* perspective, greater transparency actually makes the under-implementation problem even worse, 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. It is noticeable that regulators have created a number of disclosure requirements for crowdfunding, 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 transparency in the crowdfunding market. We find that, in contrast to its usual beneficial role in traditional markets, greater transparency in crowdfunding markets can generate a real effect that discourages crowdfunding participation and even hinders innovation.

Many believe that a major benefit of crowdfunding is providing early feedbacks to entrepreneurs.[2] The feedback effects arise because, different from monetary returns to traditional investments, for a typical reward-based crowdfunding, crowdfunding investors are 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

[1] See Regulation Crowdfunding, https://www.sec.gov/files/2017-03/RegCF_WhitePaper.pdf. For instance, for all crowdfunding campaigns including the reward-based ones, 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 feedback effects 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.

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, greater transparency in crowdfunding markets 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. 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.

To study the role of transparency in crowdfunding, we first consider an opaque regime in which the implementation cost is not revealed to market participants. 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 profit 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 under-participation in crowdfunding. Two types of uncertainty that consumers face contribute to this under-participation. First, there is *fundamental uncertainty* about the entrepreneur's implementation cost, and each 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 greater transparency in crowdfunding could alleviate the inefficiency by analyzing a transparent regime in which the implementation cost is revealed to all market participants. One may conjecture that, as such revelation reduces the uncertainty faced by consumers, it should help to improve efficiency. We find that this conjecture is not true. While revealing 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, greater transparency in the crowdfunding market actually aggravates the under-implementation problem, thus impairing efficiency.

The intuition for our result lies in how the greater transparency affects the strategic uncertainty for consumers and alters the coordination among them. Favorable news 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, unfavorable news of a high cost leads to the opposite case with a weak crowdfunding market demand and a low likelihood of product launch. That is, greater transparency coordinates the equilibrium actions of both the entrepreneur and consumers to be more extreme. Nonetheless, there is an asymmetry in the coordination effects of revealing a low cost versus a high cost. The beneficial effect of revealing 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 revealing 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, revealing a high cost significantly dampens the crowdfunding demands and deters the entrepreneur from innovating. Because of the asymmetry, *ex ante*, greater transparency 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). Two recent papers have examined the feedback role of crowdfunding and the moral hazard problem in crowdfunding markets. 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 enhancing transparency in crowdfunding markets and find that such enhancement can hinder entrepreneurial innovation.

More broadly, our paper is related to the extensive accounting and economics literature that examines the effect of information environment in financial markets (see Beyer, Cohen, Lys and Walther (2010) for a recent survey). A main insight from this literature is that, greater transparency 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 improving the crowdfunding market transparency can deter consumers from participating in crowdfunding and deter entrepreneurs from innovations. Such "real effects" of transparency, 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 transparency 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 public information in "Keynesian-beauty-contest" financial markets. Gao and Jiang (2018), Liang and Zhang (2019), and Zhang (forthcoming) examine the coordination role of accounting information in bank runs. Corona, Nan, and Zhang (forthcoming) consider the coordination role of stress tests 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 information release.

3 The Model

We consider a setting in which an entrepreneur seeks funds to launch an innovative project, for example, a new product, in a 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 launching/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.[4] 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.[5] To examine the effect of transparency in crowdfunding, we consider and compare two regimes: an opaque regime in which the cost is not revealed to the public, and a transparent regime in which the implementation cost is revealed to all market

[3] The following example illustrates how a typical reward-based 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] In practice, fund-raising targets at crowdfunding platforms usually cannot fully reveal the implementation cost, not only because the implementation cost includes non-monetary costs but also because the fund-raising target may only be a fraction of the monetary need for the new project.

[5] 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.

participants.[6]

There is a continuum of consumers, indexed by $i \in [0,1]$, who are potentially interested in the entrepreneur's product. Two independent factors collectively determine consumers' demands for a specific new product: consumers' tastes about this new product, denoted by θ_i, and their levels of enthusiasm in general for experimenting with new products/ideas, denoted by ω_i. Specifically, the factor $\theta_i \in \{\theta, 0\}$ is binary such that a consumer is either interested in the entrepreneur's product, which we refer to as an H-type, with $\theta_i = \theta > 0$, or not interested, which we refer to as an L-type, with $\theta_i = 0$. A consumer is an H-type with probability $\tilde{q}$, i.e., $\Pr(\theta_i = \theta) = \tilde{q}$, and we often refer to $\tilde{q}$ as "the market taste." The probability $\tilde{q}$ is unknown to all parties *ex ante*, but they all share a common prior that it follows a uniform distribution in the unit interval, $\tilde{q} \sim U\ [0,1]$. The other factor $\omega_i \in \{E, N\}$ is also binary: An E-type consumer ("enthusiastic" consumer) is so enthusiastic about a new product he likes, that he always wants to get it at the very first availability and thus cannot wait.[7] In contrast, an N-type consumer ("neutral" consumer) is indifferent between getting the product he likes at the first available date or later, and he does not mind waiting. A consumer is an E-type with probability $\beta \in (0,1)$ and an N-type with probability $1-\beta$. In sum, there are four groups of consumers, $\{HE, HN, LE, LN\}$. Since the LE-type and the LN-type consumers never order, we simply call them L-type consumers, who account for a fraction of $1-\tilde{q}$ of all consumers.

[6] Our paper abstracts away from modeling which factors determine the transparency in the crowdfunding market. Instead, we focus on how would greater transparency in crowdfunding affect real efficiency. In reality, several factors can contribute to greater transparency in the crowdfunding market. For instance, disclosure requirements imposed by regulators may help to improve transparency. In addition, voluntary disclosure by crowdfunding firms may also contribute to transparency.

[7] A survey by Gerber, Hui and Kuo (2012) studies why people are motivated to pre-order products on crowdfunding platforms. They find that "funders consistently reported being motivated to give to get the product first." For example, a funder who supported a film commented: "I want to see [the film] right when it's out." They also report that funders may participate in crowdfunding to be a part of the community supporting early creative ideas that are still under development. For instance, a Kickstarter contributor noted: "From an emotional standpoint, my goal is to be a part of this community of creatives." A senior executive at a crowdfunding platform also noted: "The way this model works is that people generally feel like they are involved or engaged in the project throughout the duration, and they give people opportunity to be involved in something that they maybe otherwise wouldn't have the opportunity to be involved in, so just to be a part of something is what really motivates people in those cases."

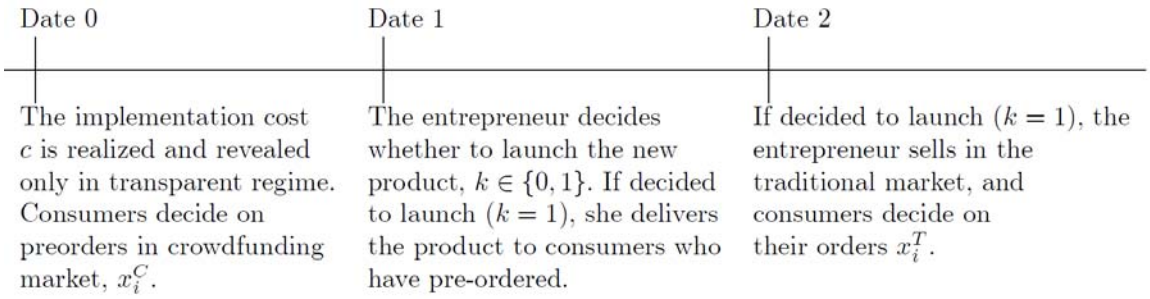

Figure 1: Time line.

The HE-type accounts for a $\beta\tilde{q}$ fraction and the HN-type accounts for a $(1-\beta)\,\tilde{q}$ fraction.[8]

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

Specifically, at date 0 when the entrepreneur approaches crowdfunding platforms to fund her new product, each consumer, given his types θ_i and ω_i, decides how many units of the new product to pre-order, denoted by $x_i^C(\theta_i, \omega_i)$. The aggregate order from the crowdfunding market is denoted by $X^C = \int_0^1 x_i^C di$. Each consumer provides Px_i^C to the entrepreneur for his pre-order, where P is the unit price the entrepreneur asks.

At date 1, after observing the total pre-orders from the crowdfunding, the entrepreneur decides whether to launch the new product. We denote the entrepreneur's subsequent implementation decision as $k \in \{0,1\}$: $k = 0$ stands that the entrepreneur gives up launching the new product whereas $k = 1$ represents the entrepreneur's decision to launch/implement the new product. If she decides not to launch the product, she returns the contribution Px_i^C to the consumers who have pre-ordered, and the game ends. Otherwise, she incurs the implementation cost c, commences

[8] To illustrate the different types of consumers, consider the crowdfunding campaign by SkyBell to sell the video doorbell given in Footnote 3. Some consumers like the doorbell (the H-type) and some do not (the L-type). Note that the L-type consumers may still be interested in and enthusiastic about being the first to get some other new products, such as a new smart watch. Among the consumers who are interested in the doorbell, some consumers (the HE-type) are so enthusiastic about the innovation of the video doorbell that they decide to pre-order the doorbell even before the doorbell is fully developed and launched. The other interested consumers (the HN-type) are less enthusiastic and willing to postpone their purchases until the video doorbells are fully launched and available in traditional retail stores.

production and delivers the products to fulfill the crowdfunding pre-orders.

At date 2, conditional on that the entrepreneur has launched the new product, she also sells the new product in the traditional mass market. We denote each consumer's order amount in the traditional market by $x_i^T(\theta_i, \omega_i)$, and the total order from the traditional market is thus $X^T = \int_0^1 x_i^T di$.

Finally, the payoffs for the entrepreneur and the consumers are as follows. 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 and the traditional markets minus the implementation cost, i.e.,

$$V(k) = k\left(PX^C + PX^T - c\right). \tag{1}$$

Since an E-type consumer, if he likes the new product, always wants it at its very first availability, he naturally chooses to pre-order in the crowdfunding market at date 0 instead of waiting for the traditional market at date 2, i.e., $x_i^T(\theta_i, E) \equiv 0$.[9] We assume that the E-type consumer's utility is

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

If the entrepreneur decides to launch the new product ($k = 1$), the E-type consumer will receive x_i^C units products that he pre-ordered at date 0, which provide him with a utility of $\theta_i x_i^C$. If the entrepreneur gives up launching the new product, the consumer will get back his initial payment/contribution, Px_i^C, from the entrepreneur. However, regardless of the entrepreneur's implementation decision, the consumer 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 other options of consumption. For example,

[9] For simplicity, we assume that enthusiastic consumers only care about getting the product from the crowdfunding market and do not enjoy consumption at a later traditional market. If we relax this assumption and allow enthusiastic consumers to enjoy consumptions at both markets, our results qualitatively remain as long as the early consumption carries a sufficiently large weight in the enthusiastic consumer's payoff. Detailed analysis is available upon requests.

if a consumer pre-orders a Pebble smart watch on the crowdfunding platform Kickstarter, he may give up opportunities to purchase other smart watches. We further assume that 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, $P = \alpha\theta_i$. α represents the bargaining power of the entrepreneur over the consumers to the extent that an entrepreneur with more bargaining power shares a larger fraction of the utility/surplus from the product.[10]

For an N-type consumer, if he is interested in the new product, since he is indifferent between getting the product at the first availability and in the later traditional market, consumption at either the crowdfunding stage or the traditional market stage provides him the same amount of utilities. Therefore, he may order at either stage, and we assume his utility function is

$$U^N(\theta_i, x_i^C, x_i^T) = k\left[(\theta_i - P)\, x_i^C + (\theta_i - P)\, x_i^T\right] - \frac{\gamma}{2}\left(P x_i^C + P x_i^T\right)^2. \tag{3}$$

Note that the two decisions x_i^C and x_i^T are made sequentially: if an N-type consumer orders from the traditional market, there is no uncertainty regarding whether he can obtain the utility $(\theta_i - P)\, x_i^T$ from his order, because before the decision of x_i^T the entrepreneur has already decided to produce ($k = 1$).[11]

[10] 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.

[11] For simplicity we assume the same quadratic cost function for an E-type or N-type consumer. Our results still hold qualitatively if we assume different cost functionss by, for example, assuming different cost parameters γ^C and γ^T. In addition, our results qualitatively remain if we assume that the unit price for crowdfunding market is different from that for traditional market, i.e., α is different.

4 Analysis

4.1 Benchmark: Complete Information

We now analyze the role of transparency 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. In this benchmark, for each type of consumers (θ_i, ω_i), we denote his choice of pre-orders in the crowdfunding market as $x_o^C(\theta_i, \omega_i)$ and choice of orders in the traditional market as $x_o^T(\theta_i, \omega_i)$. We characterize the equilibrium in the following proposition.

Proposition 1 *In the complete-information benchmark,*

- *the L-type consumers never order, i.e.,* $x_o^C(L, \omega_i) = x_o^T(L, \omega_i) \equiv 0$*;*
- *there exists a threshold* q^o*, such that each HE-type consumer orders* $x_o^C(H, E) = \dfrac{1-\alpha}{\alpha^2\gamma\theta}$ *and* $x_o^T(H, E) \equiv 0$*, each HN-type consumer orders* $x_o^C(H, N) \equiv 0$ *and* $x_o^T(H, N) = \dfrac{1-\alpha}{\alpha^2\gamma\theta}$*, 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 HE-type consumer, he pre-orders $x_o^C(H, E) = \dfrac{1-\alpha}{\alpha^2\gamma\theta}$ 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, the HN-type consumer never pre-orders in the crowdfunding market and only orders in the traditional market $x_o^T(H, N) = \dfrac{1-\alpha}{\alpha^2\gamma\theta}$ upon product launch. This is because, the HN-type consumer always (weakly)

prefers to order in the traditional market since this option offers him the same utility as pre-ordering in the crowdfunding market, but shields the consumer from the uncertainty regarding the entrepreneur's launching decision. As it turns out, in all our future analysis, it always holds that, the HE-type consumer only pre-orders in the crowdfunding market, the HN-type consumer only orders in the traditional market, and the L-type consumer never orders. To economize on notations, we thereafter suppress the dependence of x_i^C and x_i^T on the types $\{\theta_i, \omega_i\}$, denote the HE-type consumer's pre-ordering choice in the crowdfunding market by x_i^C and the HN-type consumer's ordering choice in the traditional market by x_i^T, whenever no confusion arises.

Given the equilibrium order of each 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. She then 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 and launches if and only if $q > q^o$. Moreover, it is easy to see that the threshold q^o is increasing in the implementation cost c.

4.2 Opaque Regime

We now turn to our main analysis of how transparency affects crowdfunding. We start by analyzing an opaque regime in which the market taste q is not observable to any party, and the implementation

cost c is not revealed to consumers. We solve the model by backward induction and start with the HN-type consumers' ordering decision in the traditional market at date 2. The HN-type 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 HN-type consumer chooses x_i^T to maximize his expected payoff,

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

Note that we have used the equilibrium property that $x_i^C(H, N) = 0$. Taking the first-order condition gives the equilibrium order choice for the HN-type consumer, denoted by x_{OR}^T (where OR stands for opaque regime):

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

Note that the HN-type consumers' orders are identical with those in the complete-information benchmark, i.e., $x_{OR}^T = x_o^T$. 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 HN-type consumers place their orders after observing k, their orders are the same with or without the information on c and q.

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:

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

$X_{OR}^T(q) \equiv (1-\beta)(1-q)\, x_{OR}^T$ denotes the equilibrium total orders by the HN-type consumers in

the traditional market. The entrepreneur observes the pre-orders from the crowdfunding market, X_{OR}^{C}, at date 1 as she has received them. However, she must conjecture the future orders from the traditional market $X_{OR}^{T}(q)$, 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 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 consumers' pre-ordering decisions. Since the L-type and the HN-type consumers never pre-order, the entrepreneur only needs to conjecture the pre-orders by each HE-type consumer as $\hat{x}_{OR}^{C}$. Given that conjecture, the entrepreneur rationally anticipates that, for any level of market taste q, the total pre-orders should be

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

Equating the conjectured total pre-orders $\hat{X}_{OR}^{C}(q)$ with the actual pre-orders 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:

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

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_{OR}^{T}, the entrepreneur is now able to forecast the future profits from the traditional market, and launches the product when

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

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, $\bar{X}_{OR}^C(c)$, which is a function of the implementation cost c:

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

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

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

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

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

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

Note that the HE-type 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 HE-type 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., $X_{OR}^C \geq \bar{X}_{OR}^C\left(\hat{x}_{OR}^C, c\right)$.

Importantly, two types of uncertainty get in the way when the HE-type consumers infer the entrepreneur's decision k. First, there is *fundamental uncertainty* regarding the implementation

cost c. Since c is unknown to the HE-type consumers, they can only rely on their prior beliefs 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 HE-type 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 HE-type consumer, who must coordinate his pre-order with others. Formally, note that $\dfrac{\partial E(k)}{\partial X_{OR}^{C}} > 0$, that is, HE-type consumers anticipate that the entrepreneur is more likely to launch the new product if the aggregate order X_{OR}^{C} is larger. Furthermore, from (12), each HE-type consumer's pre-order amount x_{OR}^{C} is increasing in $E(k)$. Collectively,

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

which means the HE-type 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 pre-orders from the crowdfunding market $X_{OR}^{C}(q)$ depend on q. With q unknown, each HE-type consumer infers $X_{OR}^{C}(q)$ 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, the HE-type consumers' inference of the implementation decision can be written as:

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

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

We summarize the full equilibrium of the opaque regime in the following proposition.

Proposition 2 *In the opaque regime,*

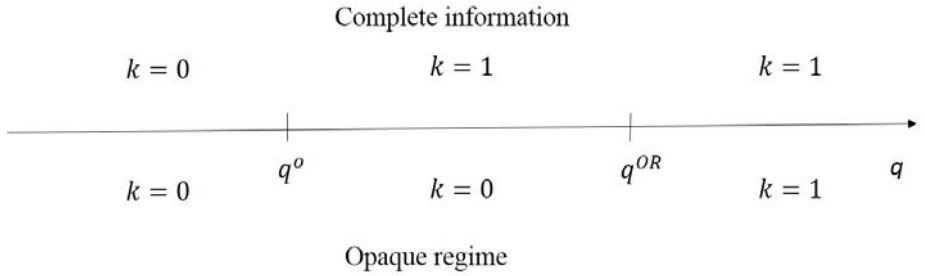

Figure 2: The implementation decision in the benchmark versus in the opaque regime.

- *each HE-type consumer pre-orders* $x_{OR}^{C} = \dfrac{(1-\alpha)\,E(k)}{\alpha^2\gamma\theta} < x_o^C$;
- *there exists a threshold* $q^{OR} \geq q^o$*, such that the entrepreneur launches the new product* ($k = 1$) *if and only if* $q > q^{OR}$*. Upon implementation* ($k = 1$)*, each HN-type consumer orders* $x_{OR}^{T} = \dfrac{1-\alpha}{\alpha^2\gamma\theta} = x_o^T$.

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 HE-type consumers place smaller pre-orders than in the complete-information benchmark, i.e., $x_{OR}^{C} < x_o^C$. 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 opaque 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 opaque 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., $q \in \left[q^o, q^{OR}\right]$): in the complete-information benchmark the entrepreneur launches the new product, while in the opaque regime she chooses not to. In sum, *ex ante*, the entrepreneur under-implements in the opaque regime.

We summarize this implementation inefficiency result in the following proposition.

Proposition 3 *In the opaque 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 total pre-orders in the crowdfunding market. 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:

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

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

In summary, our analysis of the opaque 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 HE-type 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 are there 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 revealing the implementation cost could eliminate this uncertainty and thus alleviate the under-implementation inefficiency. In the following section, we will examine a transparent regime in which the implementation cost is revealed to the market.

4.3 Transparent Regime

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

However, the pre-order decision by the HE-type consumers, denoted by x_{TR}^C, is now affected by the information of the implementation cost. In particular, conditional on the revelation of c, the HE-type consumers update their inferences of the implementation decision to be

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

Note that, while revealing c has eliminated the fundamental uncertainty regarding c, the HE-type 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 $\bar{X}_{TR}^C(c)$ is increasing in c, observing a higher implementation cost lowers the HE-type consumers' expectation of the implementation chance.

The following proposition summarizes the equilibrium of the transparent regime.

Proposition 4 *In the transparent regime,*

- *each HE-type consumer pre-orders* $x_{TR}^C = \dfrac{(1-\alpha)\,E(k|c)}{\alpha^2\gamma\theta} < x_o^C$;

- *there exists a threshold* $q^{TR} \geq q^o$, *such that the entrepreneur launches the new product* ($k = 1$) *if and only if* $q > q^{TR}$. *Upon implementation* ($k = 1$), *each HN-type consumer orders* $x_{TR}^T = \dfrac{1-\alpha}{\alpha^2\gamma\theta} = x_o^T$.

Proposition 4 indicates that the HE-type consumer's pre-order decision in the transparent regime still shows a downward distortion from that in the complete-information benchmark, i.e., $x_{TR}^C < x_o^C$. Although now the HE-type consumers observe the implementation cost and thus can better infer the implementation decision, the strategic uncertainty still exists, as each HE-type consumer remains uncertain about others' tastes at the crowdfunding stage. That strategic uncertainty continues to deter 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 revelation of c.

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

4.4 The Effect of Transparency on Under-Implementation

We have shown that, even if the implementation cost is revealed, the under-implementation inefficiency still exists. Nevertheless, one may conjecture that greater transparency should at least alleviate the under-implementation, as it 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. We find that the effect of transparency depends on the level of implementation cost that is revealed. Revealing 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, revealing c mitigates the under-implementation if $c \leq c^*$, but aggravates the under-implementation if $c > c^*$.*

The key intuition behind Proposition 6 is that greater transparency not only reduces the information asymmetry, but also affects the strategic uncertainty for consumers participating in crowdfunding and alters the coordination among them. Specifically, if the implementation cost is low, revealing that information improves the coordination in the crowdfunding market. To see this, when a low implementation cost is revealed, the HE-type 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 the consumers in crowdfunding 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 consumers to participate in crowdfunding more actively. That is, the revelation of a low implementation cost helps the 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 opaque regime.

In contrast, if the implementation cost is high, greater transparency 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, greater transparency makes the under-implementation problem even worse.

Given different implementation costs, we have shown that revealing c may alleviate or aggravate the under-implementation problem. One may wonder, *ex ante*, whether greater transparency regarding c helps to mitigate the under-implementation inefficiency. Examining the *ex ante* effect of greater transparency is relevant for generating policy implications because, in practice, regulators often contemplate on making transparency requirements for the entire crowdfunding market instead of specific projects. Towards this end, we make an *ex ante* comparison between the entrepreneur's implementation decisions in the opaque and the transparent regimes, taking into account all possible levels of implementation cost. Our analysis shows a somewhat surprising result that, *ex ante*, greater transparency always aggravates the under-implementation inefficiency.

Proposition 7 *Ex ante, revealing c always aggravates the under-implementation.*

The result in Proposition 7 is driven by an asymmetry in the coordination effects of greater transparency on under-implementation when the implementation cost is low versus when the cost is high. By Proposition 6, revealing c mitigates the under-implementation if the implementation cost c is low, but aggravates the under-implementation if c is high. Nonetheless, the benefit of revealing a low c is asymmetrically smaller than the cost of revealing 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 greater transparency still marginally mitigates the consumers' inadequate crowdfunding 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 revealing a high cost on the implementation efficiency is quite substantial. Because of the asymmetry, *ex ante*, greater transparency always aggravates the entrepreneur's under-implementation problem.

Proposition 7 sends a message of caution against the recent regulatory changes towards greater transparency in the crowdfunding market. To a large extent, such regulatory changes are motivated by the idea that transparency helps to reduce information asymmetry, which 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: greater transparency could actually deter crowdfunding and hinder innovation. The key takeaway is that transparency may heighten the level of strategic uncertainty in crowdfunding markets, 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. 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 a requirement of more transparency is not without controversy and often criticized on the grounds that it imposes a high cost on small businesses.[12] We argue that even if one ignores the exogenous cost of fulfilling the transparency requirement, the greater transparency comes with an endogenous cost. We show that improving transparency interferes with the feedback role of crowdfunding and may even cause entrepreneurs to give up new products that would have been launched absent the increase in transparency. In some sense, the transparency requirement fails to protect crowdfunding investors to the extent that, even though investors become more informed about new products thanks to the greater transparency, somewhat paradoxically, the very transparency also hinders the development of the products and prevents consumers from buying them.

[12] 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.

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Appendix I: Proofs

Proof. of Proposition 1**:** We first prove some general results in all three regimes: *In equilibrium, an HE-type consumer only pre-orders in the crowdfunding market, an HN-type consumer only orders in the traditional market, and an L-type consumer never orders.*

For an L-type consumer, since $\theta_i = 0$, either pre-ordering in the crowdfunding market (x_i^C) or ordering in the traditional market (x_i^T) always leads to negative utility due to the price P and the quadratic cost. For an HE-type consumer, as he does not get any utility from consuming in the traditional market, he only pre-orders in the crowdfunding market. Finally, for an HN-type consumer, we solve his optimal decision using backward induction. At date 2, if the entrepreneur chooses not to implement, i.e., $k = 0$, his objective function becomes

$$\underset{x_i^T}{Max} - \frac{\gamma}{2}(Px_i^C + Px_i^T)^2.$$

That is, he does not have access to the product, and thus chooses $x_o^T = 0$. However, if $k = 1$, his decision becomes

$$\max_{x_i^T} (\theta_i - P) x_i^C + (\theta_i - P) x_i^T - \frac{\gamma}{2} \left(Px_i^C + Px_i^T\right)^2.$$

Taking the first order condition gives that

$$\begin{aligned} \frac{\partial E\left[U^N\right]}{\partial x_i^T} &= (\theta_i - P) - \gamma \left(Px_i^C + Px_i^T\right) = 0 \\ &\Rightarrow \quad x_i^T = \frac{\theta - P}{\gamma P^2} - x_i^C. \end{aligned}$$

Now we move to date 0 when the HN-type consumer decides x_i^C. Since k is unobservable, we denote $E[k]$ as the consumer's expected probability of implementation. Therefore, anticipating his

subsequent decision x_i^T at date 2, the expected payoff to the HN-type consumer at date 0 is

$$\begin{aligned} & \max_{x_i^C} \left\{ (1 - E[k]) \left[-\frac{\gamma}{2} \left(P x_i^C \right)^2 \right] + E[k] \left[(\theta_i - P) x_i^C + (\theta_i - P) \left(\frac{\theta - P}{\gamma P^2} - x_i^C \right) - \frac{\gamma}{2} \left(\frac{\theta - P}{\gamma P} \right)^2 \right] \right\} \\ \Leftrightarrow \quad & \max_{x_i^C} \left\{ (1 - E[k]) \left[-\frac{\gamma}{2} \left(P x_i^C \right)^2 \right] + E[k] \left[\frac{\gamma}{2} \left(\frac{\theta - P}{\gamma P} \right)^2 \right] \right\}. \end{aligned}$$

Since the expected payoff is (weakly) decreasing in x_i^C, the HN-type consumer always chooses $x_i^C = 0$.

Now, we use the above results to prove Proposition 1. As an HN-type consumer will wait until date 2 to order in the traditional market, if $k = 1$,

$$\begin{aligned} & \underset{x_i^T}{Max} \quad (\theta_i - P) x_i^T - \frac{\gamma}{2} (P x_i^T)^2 \\ \Rightarrow \quad & x_o^T = \frac{\theta - P}{\gamma P^2} = \frac{1 - \alpha}{\alpha^2 \gamma \theta}. \end{aligned}$$

As for an HE-type consumer, we conjecture that he can perfectly anticipate the entrepreneur's implementation decision, k, provided that q and c are observable. Later we will verify this conjecture. Given the perfect anticipation, each HE-type consumer's decision becomes

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

Therefore, if he *anticipates* $k = 0$, he will not pre-order in the crowdfunding market; otherwise, if he *anticipates* $k = 1$, he will pre-order $x_o^C = \dfrac{1 - \alpha}{\alpha^2 \gamma \theta}$.

Now we look at the entrepreneur's implementation decision k. The total 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 $\frac{1-\alpha}{\alpha\gamma}q - c > 0$. Meanwhile, since each HE-type 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_{OR}^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 $\lambda \equiv \frac{\alpha\gamma}{1-\alpha}$ 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, an HE-type consumer believes that

the probability of implementation is

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

The last equation holds because $c < \bar{c} < \dfrac{(1-\alpha)\beta}{\alpha\gamma} = \dfrac{\beta}{\lambda}$, which further suggests $\dfrac{\lambda c}{(1-\beta)\,E(k)+\beta} < \dfrac{\lambda c}{\beta} < 1$. After some algebra, we can reduce (18) into:

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

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 $f_1(t)$ 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, the solution must be unique in the interval $[0, 1]$. We denote the solution as t^*, and

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

Given the belief $E(k)$, each HE-type consumer will invest $x_{OR}^C = \dfrac{t^*(1-\alpha)}{\alpha^2\gamma\theta}$ 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:

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

■

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

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

which is always satisfied. ■

Proof. of Proposition 4**:** We conjecture that an HE-type consumer can perfectly anticipate the entrepreneur's implementation strategy q^{TR} due to the revelation of c. Given this conjecture, each consumer calculates the expected probability of implementation as

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

Therefore, his optimal pre-order becomes

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

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

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

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

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

Denote q^{TR} 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 $[0, 1]$, and

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

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

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

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

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

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

which is satisfied. ■

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

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

■

Proof. of Proposition 7**:** Since q^{OR} and q^{TR} are always interior, the *ex ante* probability of implementation is equal to

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

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

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

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

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

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

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

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

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

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

Appendix II: Nash Bargaining Game for Price

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

Since consumers have the same bargaining power in the crowdfunding and the traditional markets, the equilibrium prices in the markets will be the same. We thus only discuss the bargaining game in the crowdfunding market. 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:

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