Crowdfunding: Tapping the right crowd*

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Abstract

With crowdfunding, an entrepreneur raises external financing from a large audience (the "crowd"), in which each individual provides a very small amount, instead of soliciting a small group of sophisticated investors. This article compares two forms of crowdfunding: entrepreneurs solicit individuals either to pre-order the product or to advance a fixed amount of money in exchange for a share of future profits (or equity). In either case, we assume that "crowdfunders" enjoy "community benefits" that increase their utility. Using a unified model, we show that the entrepreneur prefers pre-ordering if the initial capital requirement is relatively small compared with market size and prefers profit sharing otherwise. Our conclusions have implications for managerial decisions in the early development stage of firms, when the entrepreneur needs to build a community of individuals with whom he or she must interact. We also offer extensions on the impact of quality uncertainty and information asymmetry.

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Executive summary

In recent years, crowdfunding has become a valuable alternative source of funding for entrepreneurs seeking external financing. Existing empirical analyses report an impressive growing volume of money collected through crowdfunding worldwide. Crowdfunding allows entrepreneurs to raise funding through an open call on the Internet. An important characteristic is the extra private benefits that funders (i.e. "crowdfunders") enjoy by participating in the crowdfunding mechanism. These additional private benefits vary with the forms of crowdfunding, ranging from an equity-based model, profit-sharing scheme, and lending to outright donations. Although crowdfunding can take different forms, there is little academic understanding of the economic factors that determine an entrepreneur's choice of a particular form of crowdfunding.

This article is the first to address entrepreneur's choice in a theoretical model. It offers a comparison of two forms of crowdfunding that dominate the scene nowadays: pre-ordering and profit sharing. In the first form, entrepreneurs invite consumers to pre-order the product, to collect the necessary capital for launching production. The pre-ordering scheme enables the entrepreneur to price discriminate between two groups of consumers ("crowdfunders", who pre-purchase the product, and other "regular" consumers, who wait until the product reaches the market to purchase it) and, thereby, to extract larger profits. In the second form of crowdfunding, entrepreneurs solicit individuals to provide money in exchange for a share of future profits or equity securities. In this profit-sharing scheme, the investors may or may not decide to consume the product at a later stage.

In both forms of crowdfunding, we assume that crowdfunders enjoy some additional utility over other regular consumers. As we illustrate with real-world examples, crowdfunding is most often associated with community-based experiences that generate "community benefits" for participants. The nature of these community benefits varies with the form of crowdfunding: community benefits are linked to the consumption experience under the pre-ordering mechanism and to the investment experience under the profit-sharing mechanism.

We find that this difference in the form of extra benefits is crucial in shaping the entrepreneurial choice of crowdfunding mechanism. We find that when the initial capital requirement is relatively small entrepreneurs prefer the pre-ordering mechanism, but prefer the profit-sharing mechanism otherwise. The model derivation offers the following intuition behind this result. Pre-ordering enables the entrepreneur to price discriminate between crowdfunders and other consumers. Yet, as capital needs increase, the entrepreneur is forced to distort the pricing scheme to attract more pre-orders than what is otherwise optimal. Above some threshold, the distortion in the price discrimination becomes excessive, such that the profitability of the crowdfunding initiative decreases significantly. Conversely, crowdfunding based on profit sharing becomes more beneficial with larger amounts. This is because larger amounts induce

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the entrepreneur to solicit more individuals to participate in the financing with little effect on the fraction of profits that he or she needs to give up to obtain financing.

Building on this tradeoff, this article also provides insights into information asymmetries between entrepreneurs and crowdfunders. First, the model highlights that, initially, the entrepreneur is not able to identify the consumers with a high willingness to pay, which is private to each consumer. We show how the entrepreneur uses pre-ordering as a screening device that induces consumers to reveal their willingness to pay by self-selecting for pre-ordering. Second, in an extension we introduce additional forms of uncertainty. One form involves the uncertainty about the true quality of the product, which may only be known after production has taken place. We show that this form of uncertainty leads to qualitatively similar results. The other form is information asymmetry, which arises when entrepreneurs know the product quality better than the crowd. In general, information asymmetry tends to favor profit-sharing schemes. This is because the impossibility for consumers to ascertain product quality constrains the entrepreneur more when he or she tries to screen consumers and induce them to pre-order the product than when he or she tries to attract investors who eventually may not consume the product.

Our theoretical analysis offers managerial and empirical implications for the optimal design of crowdfunding initiatives, the impact of capital requirements, product type and market size, and the need to build the "right" community of crowdfunders. To the best of our knowledge, none of the empirical predictions have been tested so far.

1 Introduction

It is well recognized that new firms face difficulties in attracting external finance during their initial stage, be it through bank loans or equity capital (see, e.g., Berger and Udell, 1995; Cassar, 2004; Cosh et al., 2009). Many entrepreneurial ventures remain unfunded, partly because of a lack of sufficient value that can be pledged to financial investors and partly because of unsuccessful attempts to convince investors (Casamatta and Haritchabalet, 2011; Chen et al., 2009; Hellmann, 2007; Kirsch et al., 2009; Shane and Cable, 2002). To circumvent these problems, creative founders have recently employed a new source of finance – so-called crowdfunding – by tapping the "crowd" instead of specialized investors. Crowdfunding helps entrepreneurs adopt new approaches of undertaking entrepreneurial projects and managing ventures, which in turn leads to new forms of business development in which the "ordinary" crowd gets more closely involved in these firms, as active consumers, investors, or both.

The concept of crowdfunding is rooted in the broader concept of crowdsourcing, which refers to using the crowd to obtain ideas, feedback, and solutions to develop corporate activities (Bayus, 2013; Howe, 2008; Kleemann et al., 2008). In the case of crowdfunding, the objective is to collect money for investment, generally by using online social networks. In other words, instead of raising money from a small group of sophisticated investors, crowdfunding helps firms obtain money from large audiences (the "crowd"), in which each individual provides a very small amount. Such investment can take the form of equity purchase, loan, donation, or pre-ordering of the product (see Agrawal et al., 2011, 2013; Ahlers et al., 2012; Kuppuswamy and Bayus, 2013; Mollick, 2013).

Because crowdfunding can take several forms, an understanding of the entrepreneur's choice of a particular form of crowdfunding is important, especially when considering the rapid expansion of crowdfunding initiatives in recent years. For example, TikTok+LunaTik raised $941,718 from 13,512 individuals in the form of product pre-ordering of its multi-touch watch kit. Even more striking, consumers pre-ordered last-year watches from "Pebble"through Kickstarter, helping the company collect more than $10 million within a few weeks.

To address this issue, we develop a model to compare two forms of crowdfunding that have become most prevalent. In the first form, the entrepreneur invites consumers to pre-order the product (e.g., many projects on Kickstarter are funded in that form). For the entrepreneur to be able to launch production, the amount collected through pre-ordering must cover the required amount of capital. Because any remaining consumers will pay a different price when the product is on the market, pre-ordering enables the entrepreneur to price discriminate between the first group (those who pre-order and thus constitute the funding "crowd") and the second group (the other "regular" consumers who wait until the product is available to purchase it). This form of crowdfunding constitutes a special form of behavior-based price discrimination, because

consumers self-select into one group according to their personal preferences. In the second form of crowdfunding, the entrepreneur solicits individuals to provide money in exchange for a share of the profits or even to purchase equity securities issued by the firm (e.g., cartoon projects on the platform Sandawe rely on this form). These investors may or may not decide to become customers at a later stage.

In both forms of crowdfunding, the participants to the crowdfunding mechanism, whom we refer to as "crowdfunders", enjoy some additional utility over other, "regular" consumers. As we illustrate with real-world examples, crowdfunding is most often associated with community-based experiences that generate "community benefits" for participants.[1] In accordance with empirical observations, we assume that the nature of these community benefits varies with the form of crowdfunding: community benefits are tied to the consumption experience under a pre-ordering mechanism, and to the investment experience under a profit-sharing mechanism.

This difference proves crucial for comparing the two mechanisms from the entrepreneur's point of view. Our main finding reveals that, in general, the entrepreneur prefers the pre-ordering mechanism when the initial capital requirement is relatively small and prefers the profit-sharing mechanism for larger capital amounts. The intuition behind this result is as follows. A small capital requirement poses no constraint for the entrepreneur when price discriminating between crowdfunders who pre-order and regular consumers. Consumers who enjoy higher utility from consuming the good will be ready to pay more to secure additional community benefits arising from crowdfunding than other consumers, who will wait until the product is available on the market at a lower price. Through price discrimination, the entrepreneur can extract some of the community benefits from crowdfunders through this discriminatory price setting. Conversely, when the amount of capital needed is large, the entrepreneur is forced to distort the optimal pricing scheme to attract more people to pre-order; otherwise, he or she may not be able to raise enough money to begin with. The larger this distortion, the smaller are the gains from opting for pre-ordering.

This contrasts with crowdfunding through profit sharing, in which the benefits are higher when capital requirements are large. For larger capital requirements, entrepreneurs prefer to have the up-front investment financed through investor contributions rather than through pre-sales of the product, even if fewer individuals end up buying the product. This is because, under our assumptions, individuals are heterogeneous with respect to community benefits under pre-ordering but homogeneous under profit sharing. The practical implication of this difference is that the entrepreneur can more easily tax community benefits away with profit sharing than with pre-ordering. As such, the entrepreneur again can price discriminate between individuals because

[1] See Jeppesen and Frederiksen (2006), whose work examines innovative users' motivations in firm-hosted user communities. In particular, the authors show that users' motivations for participation and innovation in community are related to their desire to be recognized by the firm. Gerber et al., (2012) find similar conclusions in their study on why individuals participate in crowdfunding.

the most eager consumers will end up financing the entrepreneur to ensure that production of the good takes place.

In some cases, crowdfunding in the profit-sharing mechanism resembles donations, a form of financing not unusual in connection with crowdfunding (e.g., donation-based platforms such as GoFundMe). This occurs when crowdfunders finance the project without sharing the profits with the entrepreneur. Our analysis offers insights into when donations may be a viable form of crowdfunding. When donors expect to become future consumers and community benefits are large, they may support a project by donating money so that the entrepreneur can carry the project forward. These findings contrast with previous intuitions on donation-based entrepreneurship, in which not-for-profit organizations are the only sustainable organizational structure to access donations (Glaeser and Shleifer, 2001), such as National Geographic, the Red Cross, and Médecins Sans Frontières. According to the literature, donations arise because individuals are assumed to be altruistic. In our case, crowdfunders donate because they expect to be consumers or enjoy sufficient community benefits.

Moreover, our model offers insights into how uncertainty and information asymmetries can play a role in the design of crowdfunding initiatives. Our framework highlights the implication of self-revelation mechanisms in the course of the crowdfunding process. Although the entrepreneur faces information asymmetry initially because he or she does not know which consumers are high-utility users, the latter's participation in the financing serves as a mechanism for the entrepreneur to attract the most interested individuals, who self-select to become crowdfunders. We further explore the robustness of our results by adding in the model some uncertainty about the quality of the product to be delivered. We first show that our main result is robust to the introduction of uncertainty about the true quality of the product, which can be revealed only after the investment is sunk. We then examine two typical situations of information asymmetry between the entrepreneur, who holds private information about quality, and the consumers/investors. Considering situations of hidden *information* (i.e., the realization of quality is an exogenous event) and of hidden *action* (i.e., the realization of quality is under the entrepreneur's control), we find that, in general, such information asymmetries favor profit-sharing schemes.

Our conclusions shed light on the social environment needed to make crowdfunding a viable alternative. Building a community that supports the entrepreneur is a critical ingredient for crowdfunding to be more profitable than traditional funding. In the absence of such non-monetary benefits, price discrimination is not possible, and thus both forms of crowdfunding yield exactly the same outcome as seeking money from a bank or an equity investor. At the same time, building such a community or attracting the crowd strongly influences the strategic decision-making process in the early stage of business development. This requires integrating social networks, especially those on the Internet, into the managerial process as a mean to interact with the crowd. As we clarify subsequently, in some cases the crowd is directly involved

in some strategic decisions about product design and the exact nature of the product to be offered. Therefore, we also contribute to the managerial literature on the formation of strategic ties, which helps entrepreneurs obtain resources, either financial or with an innovative content (see, e.g., Hallen and Eisenhardt, 2012). Under crowdfunding, entrepreneurs form ties with the crowd for the strategic purpose of raising money. Regardless of the type of crowdfunding chosen (pre-ordering or profit sharing), ties formation with the crowd can be more critical for achieving superior outcomes in profit than traditional financing and for obtainingfinancing when traditional sources are not available.

We also complement the growing literature on the participation of firms in online communities. Miller et al., (2009) show that firms can benefits by making some individuals promoters of their new products. In our context, we show that crowdfunding can generate advantages over traditional funding because price discrimination results in an expansion of the market. This may help certain types of entrepreneurs achieve strategic advantages for their subsequent development by attaining higher growth trajectory early.

The remainder of this article proceeds as follows. We first offer a definition of crowdfunding, discuss crowdfunding practices, and review related literature. We then present the model and discuss its results, extensions, and implications. Finally, we conclude with suggested topics for further research.[2]

2 What is crowdfunding?

Our objective in this section is to provide insights into the various crowdfunding practices. We first provide a general definition of crowdfunding. We then present selected crowdfunding initiatives. We close this section by providing a review of the related literature.

2.1 A definition

The concept of crowdfunding comes from the broader concept of crowdsourcing, which involves using the "crowd" to obtain ideas, feedback, and solutions to develop corporate activities.[3] Kleemann et al., (2008, p. 6) state that "crowdsourcing takes place when a profit oriented firm outsources specific tasks essential for the making or sale of its product to the general public (the crowd) in the form of an open call over the internet, with the intention of animating individuals to make a [voluntary] contribution to the firm's production process for free or for significantly less than that contribution is worth to the firm." Although this definition is a useful starting point, we provide several caveats and clarifications to transpose it to crowdfunding.

[2]Developments of the model not given in the main text appear in the Appendix.

[3]The term "crowdsourcing" was first used by Jeff Howe and Mark Robinson in the June 2006 issue of *Wired Magazine* (Howe, 2008).

Although the use of the Internet to make an "open call" may be efficient for crowdsourcing in general, it can be problematic for crowdfunding, especially if it involves the offering of equity to the crowd. Indeed, general solicitation for equity offering is limited to publicly listed equity. Many countries also limit how many private investors a company can have (see Griffin, 2012; Schwienbacher and Larralde, 2012, for an extended discussion). This creates important legal limitations to crowdfunding initiatives, given that the input of the crowd is capital and not an idea or time. Therefore, most initiatives do not offer shares but provide other types of rewards, such as a product or membership. Others offer profit-sharing mechanisms in which the crowd receives a pre-specified fraction of profits from the sale of the product for their investment.

In addition, although web 2.0 is been a critical ingredient in the development of crowdfunding practices, it also differs from open-source practices (Brabham, 2008; Fershtman and Gandal, 2011). An important distinction is that in the case of open source, the resource belongs to the community, which can then exploit it on an individual basis (there is no restriction on who can use it); in the case of crowdfunding (and also crowdsourcing), the resource ultimately belongs to the firm, which is the only entity to use it. This distinction with open-source practices becomes even more evident when related to crowdfunding because capital cannot be shared. Unlike an idea or a software code, capital is not a public good, in the economic sense, that assumes non-rivalness and non-excludability.

Building on this discussion and in the spirit of Kleemann et al., (2008), we offer the following, refined definition. *Crowdfunding involves an open call, mostly through the Internet, for the provision of financial resources either in form of donation or in exchange for the future product or some form of reward to support initiatives for specific purposes.*

As mentioned previously, the promised reward can be monetary or non-monetary (e.g., recognition, voting rights). The latter encompasses many forms of crowdfunding practices. In this article, we focus on two dominant forms of crowdfunding initiatives: pre-ordering and profit sharing. According to a recent industry report (Crowdsourcing.org, 2012), these two types of crowdfunding currently prevails.[4] We provide real-case examples of these two forms in the next section. Regarding the returns from crowdfunding, no empirical study exists so far (to the best of our knowledge). The only evidence comes from the dominant platform, Kickstarter, on which the success rate is approximately 48% (see Mollick, 2013). However, it is unclear whether other platforms share the same level of success.

[4]At the end of 2011, this report listed 348 crowdfunding platforms. In a reduced sample of platforms where information is available, 43% are based on either profit sharing or pre-ordering, 15% are equity based, 14% are lending based, and the remainder are donation based.

2.2 Examples

We discuss common characteristics of crowdfunding initiatives in the light of selected cases. These initiatives may involve the financing of either a specific project or the early stage of a firm.

In 2005, the South African singer Verity Price launched the "Lucky Packet Project". To record her album without assistance of a record label, Price needed to advance an up-front investment of ZAR300,000.[5] To do so, she set up a website on which she asked people to pre-purchase her album at ZAR150 before she recorded it. In return from their contributions, she would compensate contributors with some form of non-monetary rewards, such as their name credited on her website, the possibility to vote on which songs were recorded, and the artwork and photography used for the album. In addition, 10% of sales would go to charities. Price managed to reach the threshold of ZAR300,000, with contributions from 2061 individuals. She then used the money to record her album. The album is now on the market and is sold at ZAR116.

Blender is a widely used three-dimensional animation software previously marketed and developed by Not a Number, an Amsterdam-based company. In 2002, disappointing sales along with the ongoing dot.com crisis posed serious threats to the continuing development of Blender. The Blender Foundation was then created to keep the software viable. The Blender Foundation launched a crowdfunding campaign to attempt to recover from financial distress and, ultimately, to open source Blender. The user community and customers made the funding possible and raised more than €100,000 within seven weeks. As a result of this crowdfunding campaign, the Blender Foundation continued developing and promoting Blender as a community-based open source project. In return, the crowdfunders derived consumption value from being part of the initiative.

The British crowdfunded film *The Age of Stupid* offered some of its profits to crowdfunders. Indeed, crowdfunders whose contribution exceeded £5,000 received a pro-rata share in the net profits from the film. Altogether, 258 crowdfunders invested in the film.[6] The case of MyFootballClub (who own the football club Ebbsfleet United in the United Kingdom) is also noteworthy. The contribution of fans (a membership fee of £35) allowed them to complete the takeover of the club and form a community with real decision power (members are involved in the management of the club through voting). The online community experience between investors allowed crowdfunders to enjoy additional benefits other than purely financial return

[5] At the current exchange rates (June 2013), ZAR (South African Rands) 300,000 equals approximately $30,000 or €23,000.

[6] The percentage of net profits went from 0.05% to 1%. Individuals who could not raise the necessary cash themselves (i.e., £5,000) could form syndicates by clubbing together. In this instance, one named individual bought the "share", and the different syndicate members signed a contract that formally detailed the investment agreement.

from their investment.

Other examples of profit-sharing are Seedmatch and Sandawe. The first allows the crowd to invest in a financial vehicle that then buys shares in start-ups whose goal is to attract the crowd as equity investors. Several entrepreneurial firms have succeeded in launching their crowdfunding initiative on Seedmatch, often raising up to €100,000 within a few days from 80 to 160 individual investors. In addition to earning money on their investment, participants can interact with company founders and receive updated information on the firms' most recent developments, getting in return a feeling of belonging to a community of investors. In the case of Sandawe, the crowd can view a few pages of proposed comic books and decide to offer financing. For each project, Sandawe calculates a budget that is needed to support production and launching expenses (generally in the range between €35,000 and €55,000 for an album). A project is financed by Sandawe only when this budget is achieved. Crowdfunders participate directly in the benefits of the book project being financed without holding shares. They first receive 60% of net gains from sales until they have received their initial investment and then only 40% of any remaining net gains. This splitting rule applies to any income received from the commercialization of the album during the first five years. Because these crowdfunders are mostly comic book fans, they may enjoy non-monetary benefits insofar as they contributed to the realization of the book through their investment. Many entrepreneurial ventures in other industries have been financed in the same way and share similar characteristics, such as WiSEED (finance), Spot.us (journalism), and MediaNoMad (tourism).

In summary, in addition to the pre-ordering of the product or profit sharing, these cases highlight two characteristics: (1) the high willingness to pay of crowdfunders and (2) the presence of community benefits. First, it is common for consumers who pre-order the product to pay more than regular consumers, who wait until production takes place before purchasing directly. That is, crowdfunders usually have a high willingness to pay and are motivated by more than merely consuming the product. Gerber et al.'s (2012) qualitative exploratory study provides additional supporting evidence. The authors show that crowdfunders, motivated to receive the product first along with a reward, tend to give higher amounts of money. Second, the crowd must identify themselves as such. Crowdfunders must feel that they are part of a community of "special" or "privileged" consumers/investors. This community enjoys benefits associated with either consumption or investment. Thus, consumers/investors may self-select into this community, and entrepreneurs strive to ensure that consumers/investors enjoy such community benefits and build trust in the project. Moreover, Gerber et al. (2012, p. 1) conclude that crowdfunding creates new social interactions that motivate the crowd to participate in the funding of projects, offering "feelings of connectedness to a community with similar interests and ideals" for crowdfunders.

Our analysis relies on the assumption that consumers differ in the utility they receive from

consuming the good and the community benefits associated with crowdfunding participation. The idea that consumer preferences are heterogeneous in the economy is well recognized. For example, Adner and Levinthal (2001) offer a demand-based explanation for technological changes in consumer products and, thus, technology life cycles, such that more "technologically satisfied" consumers (i.e., consumers who enjoy higher utility from technologically more advanced products) help motivate firms to innovate. Relatedly, Bauer and Hein (2006) find that in the context of Internet banking technologies, consumers are heterogeneous in their perceived risks, which in turn determines which consumers will become early adopters of new technologies. Consistent with intuition, they find that younger consumers are more likely to be early adopters because they have greater risk tolerance. Closely related to crowdfunding, Rishika et al. (2013) find that participation in and frequent interaction with companies through social media can influence consumer preferences. Some individuals are therefore more likely to become crowdfunders.

2.3 Literature on crowdfunding

Crowdfunding is a relatively new phenomenon, so it is no surprise that the related literature is only nascent. Here, we provide parallels with other sources of entrepreneurial finance to better understand the specificities of crowdfunding as a distinct form of finance. Taking crowdfunding from a purely financial perspective, we can make connections with bootstrap finance. This form of financing consists of using internal financing rather than traditional sources of external financing (e.g., bank loan, angel capital, venture capital). Several studies provide evidence of the different forms of internal sources that bootstrapping entrepreneurs use (see Bhidé, 1992; Ebben and Johnson, 2006; Winborg and Landstrom, 2001). Bhidé (1992) shows that even among the Inc. 500 companies in the United States, most started through bootstrapping. Cosh et al. (2009) analyze other financing methods for start-ups and examine a broad range of financing alternatives. Neither of these studies, however, considers the "crowd" a possible alternative (regardless of whether it comprises potential consumers or of simply profit-driven individuals).

Agrawal et al. (2011) focus on crowdfunding more specifically. They examine the geographic origin of consumers who invest on the SellaBand platform and observe that "the average distance between artist-entrepreneurs and investors is about 3,000 miles, suggesting a reduced role for spatial proximity."[7] However, they establish that distance still plays a role insofar as "local investors invest relatively early, and they appear less responsive to decisions by other investors." Mollick (2013) also examines the geography of crowdfunding using data from Kickstarter to

[7] SellaBand is an online platform based in Amsterdam that helps musicians raise money to produce their album. SellaBand's business model is as follows. Artists can post songs (demos) on the platform; visitors to the site can then listen to the music for free and choose the artists they want to invest in; artists attempt to raise $50,000 by selling "Parts" at $10 each; during the fundraising stage, money is held in an escrow until the threshold of $50,000 is reached. The $50,000 is used to fund the artist's recording project; finally, investors (the "Believers") are compensated with 10% of the revenue from the album. SellaBand is the first website of this kind; followers are, for example, Akamusic in Belgium, ArtistShare in the United States, and MyMajorCompany in France.

examine the determinants of success in crowdfunding ventures. Mollick uncovers "a strong geographic component to the nature of projects, with founders proposing projects that reflect the underlying cultural products of their geographic area."

Kuppuswamy and Bayus (2013) also examine funded projects listed on Kickstarter and show that social information (i.e., other crowdfunders' funding decisions) plays a key role in the success of a project. Ahlers et al. (2012) stress in turn the importance of information going from the entrepreneur to the crowd. Using Australian data, they analyze equity crowdfunding (i.e., crowdfunding involving equity issuance), presenting evidence that successful crowdfunding initiatives rely on credible signals, quality of the start-up, and sound information disclosure to the crowd.

When crowdfunding is associated with pre-ordering and price discrimination, literature on industrial organization provides useful insight. Nocke et al. (2011) link product pre-ordering to price discrimination in a context of information asymmetry.[8] In this case, the true quality of the product is revealed later, so the firm must deal with consumers with different expected valuations of its forthcoming product. This induces consumers with the highest expected valuation to pre-order before the quality is known. Advance purchase then leads to price discounts, in contrast with our base setting that abstracts from information asymmetry (in a subsequent section, we extend our model to incorporate related issues). We can also compare our model of pre-ordering with models of behavior-based price discrimination.[9] One main difference with this literature is that crowdfunding requires that first-period profits be above some minimum level.

3 A unified model with two crowdfunding forms

We consider an entrepreneur who wants to launch a new product. A pre-condition to launch this product is to collect an amount of capital equal to K. For un-modeled reasons, the entrepreneur has not been successful in attracting sufficient external finance to cover this amount.[10] She therefore intends to "tap the crowd". We also consider projects that do not require the involvement of a professional investor, such as a business angel or venture capitalist. Table 1 summarizes the various variables used in what follows.

[8] Other studies have shown that advance-purchase discounts can arise in environments in which production capacity is limited or the aggregate level of demand is uncertain (Dana, 1998, 1999, 2001; Gale and Holmes, 1992, 1993).

[9] See Armstrong (2007) or Fudenberg and Villas-Boas (2007) for a review. See Belleflamme and Peitz (2010, Section 10.3) for a textbook treatment.

[10] This assumption is consistent with empirical evidence that shows that entrepreneurs are limited in their access of regular sources of finance at their initial phases of development (see, e.g., Carpenter and Petersen, 2002; Cassar, 2004), notably because of their lack of a track record, agency costs, and transaction costs.

Table 1: Definition of variables.

Variable	Definition
K	Fixed amount of money needed to start production
s	Baseline quality of the good (normalized to 1)
θ	Marginal utility from increasing the quality of the good; we assume that this variable is distributed uniformly between [0,1] for consumers
n_c	Number of crowdfunders
Π, π_1, π_2	Total profits of the entrepreneur (Π), profits of the entrepreneur in the first period (π_1) and second period (π_2); by definition, $\Pi = \pi_1 + \pi_2$
Variables specific to the model of pre-ordering:	
σ	Community benefits for crowdfunders (i.e., pre-ordering consumers)
p_c, p_r	Price charged to the crowdfunders (p_c) and regular consumers (p_r); one benchmark is the price charged to consumers under traditional funding, which we denote by p_u
Variables specific to the model of profit sharing:	
Σ	Community benefits for crowdfunders (i.e., participating investors)
α	Share of profits that the entrepreneur will distribute to crowdfunders (with $0 \leq \alpha < 1$)
p	Price charged to consumers in the second period (here, the same price is charged to all consumers)

Because our focus is on the relative performance of two crowdfunding mechanisms, we simplify the modeling of the product market by assuming that (1) that the entrepreneur enjoys a monopoly position and (2) consumers know the characteristics of the products before purchase. The former assumption is not too restrictive because the examples given in the previous section suggest that crowdfunding initiatives mainly appear on niche markets (which can be approximated as local monopolies). In contrast, the latter assumption is more restrictive because anecdotal evidence suggests that entrepreneurs may use web-based crowdfunding to reveal information about the product and, thus, alleviate the experience good problem.[11] We choose to ignore this possibility in this section, but we extend the model to uncertainty and asymmetric information in Section 4.

The "crowd" that the entrepreneur can solicit for financing her project contains a unit mass of individuals. These individuals are identified as θ, with θ uniformly distributed on $[0, 1]$, and

[11] Nelson (1970) constrasts *experience* goods (whose value can only be ascertained by consuming them) with *search* goods (whose characteristics and features are easily evaluated before purchase).

have unit demand (they buy one or zero unit of the product). An individual of type θ derives surplus $U = \theta s - p$ when consuming a product of quality s sold at price p. The parameter θ is a taste parameter that measures the marginal utility of an increase in product quality.[12] Here, we take quality s as given and known by all parties (but we relax this assumption in Section 4).

To induce some consumers to finance the initial capital, the entrepreneur can choose between two crowdfunding mechanisms: she can either invite consumers to pre-order the product or ask them to advance a fixed amount of money in exchange for a share of future profits. In both cases, we assume that the crowdfunders enjoy some additional utility. As mentioned previously, entrepreneurs resorting to crowdfunding use the Internet to interact with funders, to provide them with so-called community benefits.

However, we assume that the nature of these community benefits differ in the two cases. When crowdfunding comes from pre-ordering, community benefits stem directly from the consumption experience. For example, in Verity Price's case, crowdfunders could vote on which songs were on the album and what artwork was used; in the case of Blender Foundation, crowdfunders enjoyed being part of user groups that made open source of the software possible. We model these community benefits by assuming that crowdfunders perceive an increase in the product quality. Community benefits therefore increase the crowdfunders' utility in proportion to their taste parameter: a consumer who values the product will also value the enhanced consumption experience that crowdfunding provides.

In contrast, when crowdfunding comes from profit sharing, community benefits are related more to investment than to consumption. Participating in crowdfunding is through investment, and the crowd can support the firm without necessarily becoming a consumer. Crowdfunders enjoy an increase in utility because they value the feeling of belonging to a group of "special" or "privileged" individuals (individuals who contributed to the very existence of the product). As mentioned prevoiusly, Seedmatch organizes meetings between crowdfunders and founders of the funded companies. Here, community benefits do not depend on the identity of the consumers: all crowdfunders enjoy the same increase in utility, regardless of their taste parameter. We summarize our assumptions as follows:

Assumption 1. *With crowdfunding, the entrepreneur creates community benefits that increase, in a separable way, the utility of crowdfunders. When crowdfunding comes from* pre-ordering*, crowdfunders perceive the quality of the product as equal to $s+\sigma$, with $\sigma > 0$; thus, the additional utility for a crowdfunder of type θ is $\theta\sigma$. When crowdfunding comes from* profit sharing*, the additional utility for any crowdfunder is $\Sigma > 0$.*[13]

[12] This problem was initially examined by Mussa and Rosen (1978).

[13] Arguably, individuals are also likely to have different valuations for the community benefits generated by the profit-sharing mechanism. Our formulation may thus seem restrictive. However, what matters in our analysis is how individuals *compare* community benefits across the two mechanisms. That is, we focus on $\theta\sigma - \Sigma$. This difference is a function of the parameter θ and therefore varies across individuals. So, crucial to our setting is

We next consider the two crowdfunding mechanisms in turn. We then proceed compare them, taking the point of view of the entrepreneur.

3.1 Crowdfunding and pre-ordering

In this section, we focus on crowdfunding experiences in which the enterpriser invites consumers to pre-order the product. To launch production, the amount the entrepreneur collects through pre-ordering must cover the required capital K. Because the consumers who pre-order have a high willingness to pay for the product, they will tend to constitute the bulk of the "crowd". However, an entrepreneur is usually unable to identify these consumers. The entrepreneur must then use some self-selecting device to induce high-paying consumers to reveal themselves. The kind of community experience the web-based crowdfunding offers may be the means by which the entrepreneur enhances the perceived quality of the product. In this sense, crowdfunding is a special form of behavior-based price discrimination.

The timing of the game is as follows (see Figure 1): In the first period, the entrepreneur sets the pre-ordering price p_c (with subscript c for "crowdfunders"), and consumers decide whether to pre-order at that price. Let n_c denote the mass of crowdfunders (i.e., of consumers who decide to pre-order). If $n_c p_c < K$, insufficient capital is collected and the game stops. The crowd then receives its money back. Otherwise, if $n_c p_c \geq K$, the game moves to the second period in which the entrepreneur sets p_r, the price for consumers who did not pre-order in period 1 (with subscript r for "regular consumers"). These consumers then decide to buy or not (observing all the previous steps). Note that this timing assumes that the entrepreneur is not able to commit to the second-period price p_r in period 1. This seems reasonable because the very existence of the product is itself uncertain in period 1.[14] Utilities and profits accrue at the end of period 2. Without loss of generality, we assume no discounting and normalize $s = 1$. We solve the game backward for its subgame-perfect Nash equilibrium.[15]

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that individuals are heterogeneous in the way they value the *difference* between the community benefits in the two mechanisms. Therefore, adding another source of heterogeneity in the profit-sharing mechanism would only muddle the analysis without bringing extra insights. Moreover, our approach is consistent with the assumption that investors differ in their value of Σ but that the heterogeneity across Σ is uncorrelated with the level of product quality s.

[14] As we describe subsequently, the ability to commit or not to the period 2 price proves crucial when comparing the two crowdfunding mechanisms.

[15] In principle, we could include more than one price for crowdfunders, each with a different level of community benefits. The entrepreneur could vary the level of community benefits (as done in many projects on Kickstarter) by offering different types of rewards (e.g., a T-shirt only for crowdfunders who pay a lower price and a T-shirt and a telephone call for those paying a higher price). This would complicate the model resolution without adding new insights. We can easily conjecture that a wider menu of options would allow the entrepreneur to extract more consumer surplus. However, the cost of administering a wider set of options (and the possible confusion that it induces for consumers) should also be factored in. Thus, it is not clear a priori whether including more options would extend the profitability of the pre-ordering scheme or not.

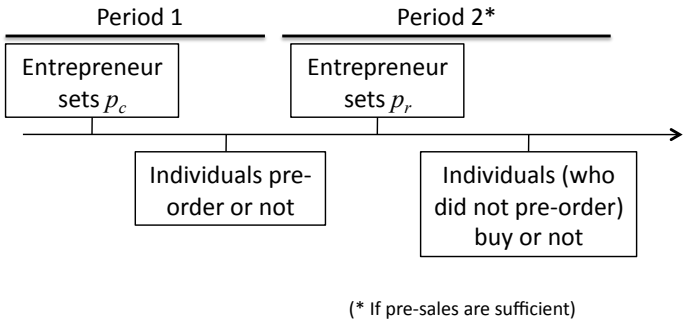

Figure 1: Timeline under pre-ordering scheme

Period 2. Suppose that $n_c \in (0,1)$ consumers pre-ordered in period 1 and that $n_c p_c \geq K$. Then, the indifferent consumer between pre-ordering and not can be identified by a taste parameter $\theta_c = 1 - n_c$. Consumers who can potentially buy the product at period 2 are such that $\theta \in [0, \theta_c]$. Facing p_r, they buy iff $\theta - p_r \geq 0$, or $\theta \geq p_r \equiv \theta_r$. Thus, assuming for simplicity zero marginal cost of production,[16] the entrepreneur faces the following program at period 2: $\max_{p_r} p_r (\theta_c - p_r)$. The optimal price and second-period profit are easily identified as $p_r(\theta_c) = \theta_c/2$ and $\pi_2(\theta_c) = \theta_c^2/4$.

Period 1. The indifferent consumer between pre-ordering and not is identified by θ_c, such that $\theta_c(1+\sigma) - p_c = \theta_c - p_r$ or $\theta_c = (p_c - p_r)/\sigma$. In period 1, consumers observe the value of p_c and can anticipate that the entrepreneur will set the value of p_r in period 2, which we derived previously. Thus, we have the following:

$$\theta_c = \frac{1}{\sigma}\left(p_c - \frac{\theta_c}{2}\right) \Leftrightarrow \theta_c = \frac{2p_c}{1+2\sigma}.$$

We can then write the entrepreneur's maximization program in period 1 as

$$\max_{p_c} p_c \left(1 - \frac{2p_c}{1+2\sigma}\right) + \frac{1}{4}\left(\frac{2p_c}{1+2\sigma}\right)^2,$$

under the following constraints

$$\pi_1 \equiv p_c \left(1 - \frac{2p_c}{1+2\sigma}\right) \geq K, \text{ and } 0 \leq \frac{2p_c}{1+2\sigma} \leq 1.$$

The unconstrained optimum is given by the first-order condition:

$$p_c^* = \frac{(1+2\sigma)^2}{2(1+4\sigma)}. \tag{1}$$

[16] In this linear model, we make this assumption without loss of generality. Prices can simply be reinterpreted as markups above a constant marginal cost.

The first constraint is satisfied if $\pi_1 \geq K$, which we can rewrite as

$$K \leq \frac{\sigma\left(1+2\sigma\right)^2}{\left(1+4\sigma\right)^2} \equiv \bar{K}.$$

For the second set of constraints, we compute $\theta_c^* = 2p_c^*/\left(1+2\sigma\right) = \left(1+2\sigma\right)/\left(1+4\sigma\right)$. This value is clearly positive and smaller than unity; the second set of constraints is thus satisfied.

Unconstrained case. If $K \leq \bar{K}$, we can use the values of p_c^* and θ_c^* to compute, respectively, the optimal profit in period 1 (π_1^*) and that in period 2 (π_2^*), to derive the total profit at the unconstrained optimum:

$$\Pi^* = \pi_1^* + \pi_2^* - K = \frac{\left(1+2\sigma\right)^2}{4\left(1+4\sigma\right)} - K.$$

Before considering the constrained case, it is useful to compare the results in the unconstrained case to two benchmarks. First, regarding the effect of price discrimination, we can compare prices p_c^* and p_r^* with the uniform price that the entrepreneur would set were she not able to price discriminate. If we denote this unform price by p_u, the indifferent consumer would be such that $\theta - p_u = 0$. The entrepreneur would then choose p_u to maximize $p_u\left(1-p_u\right)$. Consequently, the entrepreneur would set $p_u = 1/2$, all consumers with $\theta \geq 1/2$ would purchase the product, and gross profits would be equal to $1/4$.

Comparing the pre-ordering scheme with uniform pricing, we confirm that crowdfunders pay a larger price while regular consumers buy the product at a discount:

$$p_r^* = \tfrac{1}{2} - \tfrac{\sigma}{1+4\sigma} < p_u = \tfrac{1}{2} < p_c^* = \tfrac{1}{2} + \tfrac{\sigma^2}{1+4\sigma}.$$

The pre-ordering scheme also expands the market: the marginal consumer is indeed identified by $\theta_r^* = \left(1+2\sigma\right)/\left(2\left(1+4\sigma\right)\right) < 1/2$. Taken together, we observe that the pre-ordering scheme allows the entrepreneur to increase profits with respect to uniform pricing:

$$\Pi^* = \frac{\left(1+2\sigma\right)^2}{4\left(1+4\sigma\right)} - K = \frac{1}{4} + \frac{\sigma^2}{1+4\sigma} - K > \frac{1}{4} - K.$$

A second benchmark is the case in which the entrepreneur is able to commit in period 1 to the price that prevails in period 2. The entrepreneur's maximization program in period 1 would then be given by

$$\max_{p_c,p_r}\left(1-\frac{p_c-p_r}{\sigma}\right)p_c + \left(\frac{p_c-p_r}{\sigma} - p_r\right)p_r \;\text{ s.t. }\; 1 \geq \frac{p_c-p_r}{\sigma} \geq p_r \geq 0.$$

We confirm that the optimal prices would then be $p_c = \left(1+\sigma\right)/2$ and $p_r = 1/2$. At these prices, $\left(p_c - p_r\right)/\sigma = p_r$, meaning that no individual finds it profitable to buy the product in period 2

(thus forgoing the community benefits σ). In other words, when the entrepreneur can commit to the period 2 price, she optimally chooses not to open the market in period 2.[17] She then only attracts crowdfunders, who are willing to pay $\theta(1+\sigma)$ for the product. We compute the corresponding profit as $(1+\sigma)/4 - K$, which we easily show to be larger than Π^*. This result, that the entrepreneur is hurt by her inability to commit to future prices, also occurs in settings with durable goods or with behavior-based price discrimination.

Constrained case. If $K > \bar{K}$, the unconstrained optimal price and number of crowdfunders are insufficient to cover the capital requirement. Then, we compute p_c as the solution to $\pi_1 = K$; that is,

$$p_c\left(1 - \frac{2p_c}{1+2\sigma}\right) = K \Leftrightarrow 2p_c^2 - (1+2\sigma)\,p_c + (1+2\sigma)\,K = 0.$$

For this polynomial to have real roots, we need $K < (1+2\sigma)/8 \equiv \hat{K}$. In other words, there is a threshold for the initial capital requirement above which the entrepreneur is unable to finance her venture through crowdfunding and pre-ordering.[18]

If $K < \hat{K}$, the two roots are such that $0 < p_c^- < p_c^+ < (1+2\sigma)/2$, which ensures that $0 < \theta_c < 1$. Although both prices achieve the required profit in the first period, the entrepreneur prefers the largest price because the second-period profit increases with p_c. Thus, the firm sets

$$\bar{p}_c = \frac{1}{4}\left(1 + 2\sigma + \sqrt{(1+2\sigma)(1+2\sigma-8K)}\right).$$

Comparing the latter value with the unconstrained price given in (1), we can confirm that $K > \bar{K}$ means that $\bar{p}_c < p_c^*$. That is, the entrepreneur is constrained to charge a lower price to crowdfunders. She therefore compensates by attracting more of them: the size of the population of crowdfunders increases with the amount that must be funded.

It follows that $\bar{\pi}_1 = K$, and we compute $\bar{\pi}_2$ (which is equal to the total profit $\bar{\Pi}$) as

$$\bar{\Pi} = \bar{\pi}_2 = \left(\frac{\bar{p}_c}{1+2\sigma}\right)^2 = \frac{1}{16}\left(1 + \sqrt{\frac{8}{1+2\sigma}(\hat{K}-K)}\right)^2.$$

Note that $\bar{\Pi}$ decreases with K. The smallest profit is reached for $K = \hat{K}$ (i.e., the largest

[17] This is a standard result for second-degree price discrimination. Salant (1989) shows that when utilities and costs are linear, a monopolist prefers to offer a single version of its product, thus refraining from price discrimination.

[18] Recall that we simplified the model using several normalizations. In addition to the quality of the product, s, which we set equal to 1, we normalized the mass of consumers and the maximum willingness to pay for the product (the upper bound on the distribution of θ) to unity. More generally, we could set the mass of consumers equal to M, and the maximum willingness to pay to T. In this more general model, we can easily confirm that all the thresholds on K would be multiplied by M and T (and would increase, non-linearly, with s). Thus, in our simplified model, the maximum amount of capital that the entrepreneur can raise through crowdfunding is relative to the size of the product market (measured by the parameters s, M, and T, which are all set equal to 1 here).

amount of capital that can be financed through pre-ordering): $\bar{\Pi} = 1/16$. For $\sigma < 1/4$, the entrepreneur would then prefer to sell the good at the uniform price p_u and make a profit equal to $1/4 - \hat{K}$. This illustrates the ins and outs of crowdfunding based on pre-ordering compared with more traditional funding sources. On the one hand, crowdfunding has the advantage of offering an enhanced experience to some consumers and, thereby, of allowing the entrepreneur to practice a form of behavior-based price discrimination, which can increase profits by extracting a larger share of consumer surplus. On the other hand, the disadvantage is that the entrepreneur is constrained in the first period by the amount of capital she needs to raise. This distorts the entrepreneur's price discrimination strategy. The larger this amount, the larger is the number of consumers the entrepreneur must attrack to cover it, which eventually reduces the profitability of the pre-ordering scheme.

With these results, we can state the following lemma:

Lemma 1 *The entrepreneur's profit under crowdfunding/pre-ordering is equal to*

$$\Pi_p = \begin{cases} \frac{1}{4} + \frac{\sigma^2}{1+4\sigma} - K & \text{for } K \leq \bar{K}, \\ \frac{1}{16}\left(1 + \sqrt{\frac{8}{1+2\sigma}(\hat{K} - K)}\right)^2 & \text{for } \bar{K} \leq K < \hat{K}, \\ 0 & \text{for } \hat{K} \leq K, \end{cases} \tag{2}$$
$$\text{with } \bar{K} = \frac{\sigma(1+2\sigma)^2}{(1+4\sigma)^2} \text{ and } \hat{K} = \frac{1+2\sigma}{8}.$$

It is intuitive, and clear from expression (2), that the entrepreneur's profit decreases with the amount of capital to be raised (K). We can also readily confirm that the profit increases with the magnitude of the community benefits (σ). This occurs for two reasons: First, an increase in σ raises the surplus of crowdfunders, which the entrepreneur can partially capture. Second, the constraint imposed by the capital requirement becomes relatively less stringent as σ increases: the difference $\hat{K} - \bar{K}$ is a decreasing function of σ.

3.2 Crowdfunding and profit-sharing

We now examine a different crowdfunding mechanism in which consumers provide money to the entrepreneur in exchange for a share of the profits. In this case, financing and consumption decisions are not automatically related: individuals may decide to invest but not consume, or vice versa. As explained previously, crowdfunders still enjoy some extra utility from participating in the crowdfunding mechanism, but these community benefits are now detached from the consumption of the product. In particular, crowdfunders enjoy benefits through their investments decisions and thus see their utility increased by Σ regardless of their taste for product quality.

The timing of the game is now as follows (see Figure 2): In period 1, the entrepreneur sets the share α of the profits she will distribute to crowdfunders (with $0 \leq \alpha < 1$); consumers

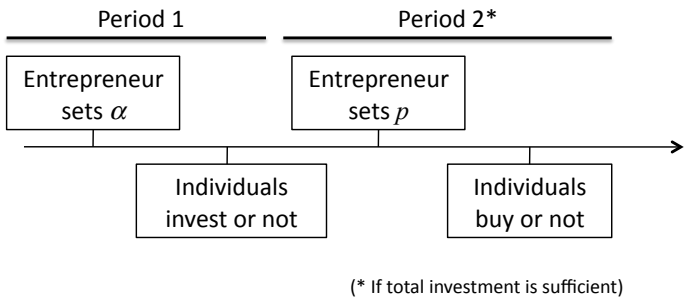

Figure 2: Timeline under profit-sharing scheme

decide then whether to become crowdfunders or not. In period 2, the entrepreneur sets the price of the product, and consumers decide whether to buy the product or not. As in the previous section, we assume that utilities and profits accrue at the end of period 2 and that there is no discounting. We solve the game backward for its subgame-perfect Nash equilibrium.

Period 2. With this crowdfunding mechanism, the investment decision no longer affects the consumers' valuation of the product, because Σ is linked to investment and not consumption. The entrepreneur's maximization problem in period 2 is therefore the uniform-pricing problem that we described previously. Recall that the demand function is simply $D(p) = 1 - p$. Thus, the profit-maximization price is $p = 1/2$, and the corresponding profit is $\pi = 1/4$. At price $p = 1/2$, consumers with $\theta \in [1/2, 1]$ buy the product, and consumers with $\theta \in [0, 1/2]$ do not buy.

Note that under the profit-sharing mechanism, the entrepreneur no longer faces the commitment problem we identified under the pre-ordering mechanism. Here, it is clear for all individuals from the outset that the product market will only be open in period 2.

Period 1. To determine whether consumers are willing to invest or not, we need to distinguish between those who decide to buy the product in period 2 and those who do not. For those who buy, that is, the consumers with $\theta \in [1/2, 1]$, the incentive constraint for investing is

$$\theta - \frac{1}{2} + \frac{\alpha}{n_c}\frac{1}{4} - \frac{K}{n_c} + \Sigma \geq 0.$$

On the left-hand side, the first two terms are the net utility from consuming the product, the third term is the share of profits that the crowdfunder receives (where n_c denotes the number of crowdfunders), the fourth term is the money that the crowdfunder is asked to pay to the entrepreneur (which decreases with the number of crowdfunders because the capital requirement K can be split among a larger crowd), and the fifth term is the community benefits that accrue to crowdfunders. We set the outside option, on the right-hand side, to zero. This corresponds

to the idea that consumers form the belief that if they do not invest, the product will not be launched; in other words, all investors assume that they are pivotal. As we will discuss subsequently, such beliefs are consistent because the entrepreneur will always choose the value of α, which restricts the number of individuals n_c in such a way that their participation is needed to raise the amount K. Therefore, every individual becomes pivotal. In equilibrium, the selected individuals are those with the highest θ.

We can then identify the marginal investor as the consumer for whom the previous equation holds with equality:

$$\theta_i = \frac{1}{2} - \left(\frac{\alpha}{n_c} \frac{1}{4} - \frac{K}{n_c} + \Sigma \right). \tag{3}$$

We note that $\theta_i > 1/2$ if and only if the net utility from investing is negative: $\frac{\alpha}{n_c}\frac{1}{4} - \frac{K}{n_c} + \Sigma < 0$.

For the individuals who do not buy in period 2, that is, those with $\theta \in [0, 1/2]$, the incentive constraint for investing is simply

$$\frac{\alpha}{n_c} \frac{1}{4} - \frac{K}{n_c} + \Sigma \geq 0. \tag{4}$$

Here, the outside option (the right-hand side of the condition) is simply equal to zero.

Thus, the entrepreneur can choose between two options. First, she can set α in such a way that constraint (4) is satisfied, thereby making the investment attractive in itself for all individuals. In that case, the entrepreneur can turn all individuals into investors (i.e., raise n_c up to 1) if it is profitable to do so. Second, she can violate constraint (4) and make the investment only profitable for buying consumers with a high valuation for the product ($\theta \geq \theta_i$): even though the investment is not profitable in itself, these consumers are willing to accept losses from their first-period investment to ensure that the product will be launched. Comparing the two options allows us to state the following two lemmata (we relegate the technical proofs to Appendix 7.1).

Lemma 2 *When crowdfunding is based on profit-sharing, the entrepreneur can choose to invite only buyers of the product (small investor base) or anyone (large investor base) to become investors. (a) The two options are equivalent when the capital to be raised is very small, because they both lead the entrepreneur to distribute no profit. (b) The two options are also equivalent when the capital to be raised is large, because neither option allows the entrepreneur to launch the venture. (c) For intermediate levels of capital, inviting only buyers to become investors is the dominant option only if community benefits are fairly small; otherwise, inviting any individual to become an investor is the preferred option.*

The first result is striking: although our model assumes that individuals have purely egocentric preferences, a form of "donation" may occur at equilibrium. When the capital requirement is sufficiently small, the entrepreneur may use the crowd to finance it without needing to distribute any profit in return: community benefits and/or utility from consumption are sufficient

for motivating individuals to participate in the crowdfunding mechanism. The second result is not suprising: for the pre-ordering mechanism, there is an upper bound on the size of projects that can be financed through profit sharing (this upper bound is defined in the lemma 3). Finally, the intuition behind the third result is as follows: when community benefits are large enough, the entrepreneur can make the net utility from investing positive – and thereby attract a large base of crowdfunders – without distributing too much of the profits; conversely, when community benefits are small, the entrepreneur prefers to obtain funds from a small crowd of consumers with a high willingness to pay; these consumers agree to finance the venture even though their net utility from investing is negative.

In the lemma 3, we express the entrepreneur's profit function when she bases crowdfunding on profit sharing (and selects the best option – small or large base of crowdfunders – for each combination of parameters).

Lemma 3 *The entrepreneur's (residual) profit under crowdfunding/profit-sharing is equal to*

$$\begin{aligned} \Pi_s &= \begin{cases} \frac{1}{4} & \text{if } 0 \leq K \leq f(\Sigma), \\ \frac{1}{4} + f(\Sigma) - K & \text{if } f(\Sigma) \leq K \leq f(\Sigma) + \frac{1}{4}, \\ 0 & \text{if } K \geq f(\Sigma) + \frac{1}{4}. \end{cases} \\ \text{with } f(\Sigma) &= \frac{(1+2\Sigma)^2}{16} \text{ for } \Sigma < \frac{3}{2} - \sqrt{2} \simeq 0.086 \text{ and } f(\Sigma) = \Sigma \text{ otherwise.} \end{aligned} \tag{5}$$

It is intuitive, and obvious from expression (5), that the entrepreneur's profit weakly decreases with K and weakly increases with Σ. Note also that when crowdfunding with profit sharing allows the entrepreneur to operate (i.e., for $K < f(\Sigma) + 1/4$), it yields a larger profit than the traditional scheme based on uniform pricing and other sources of funding. Recall from the previous section that profit under the latter scheme is equal to $1/4 - K$.[19]

3.3 Comparison of crowdfunding mechanisms

We compare the two crowdfunding mechanisms from the point of view of the entrepreneur. Our goal is to identify the configurations of parameters for which the entrepreneur prefers one or the other mechanism. Therefore, we compare the equilibrium profits given in expressions (2) and (5). The magnitude of the community benefits in the two mechanisms, σ and Σ, play an important role in the comparison: the larger σ is relative to Σ, the more likely the entrepreneur will prefer pre-ordering to profit sharing, and vice versa. It would be incorrect, however, to conjecture that one mechanism strictly dominates the other as soon as the difference in community benefits goes beyond some threshold. Rather the choice between mechanisms also depends on the amount of capital the entrepreneur must raise, as stated in the following proposition.

[19] We would need to qualify this result if we assumed that the entrepreneur had to incur some cost to provide community benefits to her crowdfunders (here, we have implicitly assumed that this cost is zero).

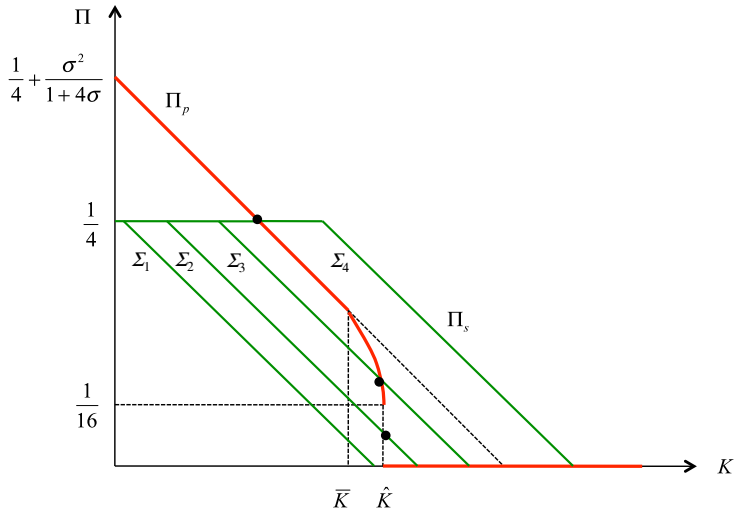

Figure 3: Profits in the two crowdfunding mechanisms

Proposition 1 *If $\sigma > 1/2$ and $f(\Sigma) < (2\sigma - 1)/8$, then the entrepreneur prefers pre-ordering over profit sharing for any value of K. Otherwise, there always exists a cut-off value K_{ps}, such that the entrepreneur prefers pre-ordering for $K < K_{ps}$ and profit sharing for $K > K_{ps}$.*

The proof of this proposition – and the exact value of K_{ps} – appears in Appendix 7.2. We can show the results graphically by plotting the profits in the two mechanisms as a function of the amount of capital K, as in Figure 3. To cover all potential scenarios, we deliberately choose to represent the pre-ordering profit Π_p for a large value of σ, namely $\sigma > 1/2$. We then draw the profit-sharing profit Π_s for increasing values of Σ, namely $0 < \Sigma_1 < \Sigma_2 < \Sigma_3 < \Sigma_4$. As the figure shows, pre-ordering dominates for any value of K when $\Sigma = \Sigma_1$. Then, when we increase Σ successively to Σ_2, Σ_3, and Σ_4, the threshold value K_{ps} becomes smaller; that is, as community benefits in the profit-sharing mechanism increase (relative to community benefits in the pre-ordering mechanism), the range of values of K for which profit-sharing dominates also increases.

The intuition behind Proposition 1 is as follows. A small capital requirement poses no constraint for the entrepreneur, no matter the crowdfunding mechanism she chooses to implement. That is, with pre-ordering, she can set the optimal discriminating prices, and with profit sharing, she does not need to distribute any profit. The difference comes from pre-ordering in which a larger share of consumers buy the product, rather than profit sharing, which generates higher revenues for the entrepreneur. The net profit is thus larger under pre-ordering than under profit sharing. Yet the gross profit may be lower: under pre-ordering, the entrepreneur must still deduct the fixed-cost K, while under profit sharing, no deduction is required because K is

entirely covered by the investors' contributions. Thus, pre-ordering dominates only as long as K is not too large. As K increases, the entrepreneur prefers to have the capital financed through investors' contributions rather than through pre-sales of the product.

This argument follows from the nature of the community benefits in the two mechanisms. Individuals are heterogeneous with respect to community benefits under pre-ordering but homogeneous under profit sharing. The practical implication of this difference is that the entrepreneur can more easily tax community benefits away with profit sharing than with pre-ordering.

So far, we have allowed for any combinations of σ and Σ. We could, however, impose some relationship between the extent of community benefits under the two mechanisms. A natural benchmark would be to impose *ex ante identical total community benefits* in the two mechanisms; that is

$$\Sigma = \int_0^1 \theta\sigma d\theta \Leftrightarrow \Sigma = \frac{\sigma}{2}.$$

In that case, we can state (see Appendix 7.2 for a proof):

Corollary 1 *If total community benefits are ex ante identical in the two mechanisms (if $\Sigma = \sigma/2$), then the entrepreneur chooses pre-ordering for $K < \sigma^2/(1+4\sigma)$ and profit sharing otherwise.*

4 Uncertainty about product quality

Because crowdfunding initiatives involve the introduction of new products and services, they occur in environments in which uncertainty and information asymmetries are prevalent. However, crowdfunding initiatives often rely on products that are not yet on the market in finished form. Furthermore, many times, entrepreneurs only offer a description and promise on what the final product will be.

Thus far in our analysis, there was no uncertainty, and asymmetric information was only present on the demand side.[20] In this section, we test the robustness of our results by introducing in the model some uncertainty about the quality of the product.[21] To do so, we proceed in three steps. First, we assume symmetric information: both the entrepreneur and individuals are uncertain about the product quality, which is revealed only when the investment K is sunk. In the second and third extensions, there is asymmetric information insofar as the entrepreneur holds private information about the quality of the product. We consider in turn situations of

[20] Potential consumers hold private information about their willingness to pay for the entrepreneur's product. In particular, individuals know their own θ while the entrepreneur only knows the distribution. In this respect, the entrepreneur could use pre-ordering as a screening device that induces consumers to reveal their willingness to pay (by self-selecting or not for pre-ordering).

[21] Equivalently, we could assume that there is uncertainty about whether the entrepreneur can deliver the product, leading to operational uncertainty that, in this case, would be borne by crowdfunders if the investment K is lost.

hidden *information* and hidden *action* by assuming that the realization of quality is either an exogenous event or is under the entrepreneur's control.

4.1 Symmetric information

In the previous section, we assumed that the quality of the good to be produced was certain (i.e., of level s). In this section, we show that our results are robust to introducing uncertainty about the quality when both parties (entrepreneur and individuals) face the same (lack of) information. For simplicity, we assume that the product quality is $s+\Delta$, with probability $1/2$, and $s-\Delta$, with probability $1/2$, where $0<\Delta<s$.[22] We assume that the true quality (i.e., either $s+\Delta$ or $s-\Delta$) is only realized after the investment K is made so that in either case the money is sunk. It follows that when making decisions, the entrepreneur does not have more information than the individuals: information is symmetric. As previously, we set $s=1$. We further assume that all the parties are risk neutral.

Under pre-ordering, the indifferent individual θ_c is such that

$$\theta_c\left(\tfrac{1}{2}(1+\Delta)+\tfrac{1}{2}(1-\Delta)+\sigma\right)-p_c=\tfrac{1}{2}\left(\theta_c(1+\Delta)-p_r^+\right)+\tfrac{1}{2}\left(\theta_c(1-\Delta)-p_r^-\right),$$

where $p_r^+=\frac{1}{2}\theta_c(1+\Delta)$ ($p_r^-=\frac{1}{2}\theta_c(1-\Delta)$) represents the price for regular consumer if quality is $1+\Delta$ ($1-\Delta$). Simplifying and inserting the values of p_r^+ and p_r^- into the condition, we obtain $\theta_c=2p_c/(1+2\sigma)$, just as in the base model. The entrepreneur's maximization problem in period 1 is therefore unaffected as is the choice of crowdfunders (because the expected price in period 2 is $\frac{1}{2}p_r^++\frac{1}{2}p_r^-=\frac{1}{2}\theta_c$, just as in the absence of uncertainty). That the results are unaffected is a consequence of the particular assumptions made with regard to uncertainty (where the expected quality level is s, the same as in the base model); it is not a general outcome.

Under profit-sharing, the entrepreneur's maximization problem in period 2 is similar: individuals buy if their expected net utility is positive, that is, if $\frac{1}{2}\theta(1+\Delta)+\frac{1}{2}\theta(1-\Delta)\geq p$ or if $\theta\geq p$, which induces the same demand function as in the absence of uncertainty. Assuming (as we have done implicitly so far) that both qualities are produced at the same marginal cost of zero, the entrepreneur's maximization problem is also the same as in the previous section. It follows that consumers with $\theta\in[1/2,1]$ buy the product and consumers with $\theta\in[0,1/2]$ do not buy. Again, because the expected price is $1/2$ for the crowd at the time it considers participating in the funding in period 1, the maximization objectives of the crowd and, thus, of the entrepreneur are unaffected.

Overall, our tradeoff is robust to introducing uncertainty about product quality. Under the specific assumptions made in this section, we obtain the same outcome as in Proposition 1.

[22] The parameter Δ indicates the magnitude of the uncertainty: an increase in Δ represents greater variability of the quality level.

However, in general the introduction of such an uncertainty will affect the cutoff level for K in the tradeoff and it is unclear whether it affects one form more than the other; any statement on comparison depends on the specific assumptions made. Qualitatively speaking, however, the result stated in Proposition 1 should continue to hold, because we expect only a shift in the cutoff level but not a fundamental change in the decision-making process of the entrepreneur or the crowd.

Finally, note that our previous result on differences in prices charged to crowdfunders and regular consumers under pre-ordering still holds, but should now be interpreted probabilistically (i.e., *in expectations*, crowdfunders are charged a higher price than regular consumers). Ex post, crowdfunders will at times pay less if the true quality turns out to be significantly higher than expectations made in period 1 of quality outcome. In general, however, crowdfunders should pay more.

4.2 Asymmetric information

We now assume that the entrepreneur is in a position to learn the true quality of the product before the consumers/investors. Thus, there is asymmetric information, and two typical situations can be considered: *hidden information*, if the realization of quality escapes the entrepreneur's control (creating an *adverse selection* problem), or *hidden action*, if the entrepreneur can decide on the level of quality before the game starts (creating a problem of *moral hazard*). In this section, we examine the former situation formally and then conjecture about the latter situation, which is inherently more complex to handle.

4.2.1 Exogenous quality realization

Suppose that the entrepreneur offers a product of either high quality (denoted by s_H) or low quality (denoted by $s_L < s_H$), with respective marginal costs c_H and c_L; we assume that high quality is more costly to produce than low quality: $c_H > c_L \geq 0$. In this subsection, we assume that the realization of quality is an exogenous event that is beyond the entrepreneur's control. Asymmetric information results from the realization of quality being observed by the entrepreneur but not the consumers (who have no way to check the quality of the product before they actually consume it). Consumers only know that the quality is s_H with probability λ and s_L with probability $1 - \lambda$. Thus, the expected quality (s^e) depends on the consumers' beliefs; $s^e = s_L$ (s_H) if consumers believe that only the low (high) quality is on the market, or $s^e = \lambda s_H + (1 - \lambda) s_L \equiv \bar{s}$ if they believe that both qualities can be offered on the market. The game is then solved for its Perfect Bayesian Nash equilibria (PBNE).[23]

[23] Belleflamme and Peitz (2010, p. 686) defines a PBNE as "a strategy profile and a belief system such that the strategies are sequentially rational given the belief system and the belief system is consistent, wherever possible, given the strategy profile."

The full resolution of the entrepreneur's choice between the two forms of crowdfunding is rather involved and, therefore, goes beyond the scope of this article. Nevertheless, we can examine how information asymmetry affects the largest project size (i.e., the upper bound on K) that can be financed under the two crowdfunding mechanisms. Appendix 7.3 provides the detailed derivations.

Under pre-ordering, recall from the previous section that the largest project size that can be financed (under symmetric information and no uncertainty) is given by the threshold $\hat{K}$, as defined in expression (2). Recall also that this threshold corresponds to the value of K such that the equation $\pi_1 = K$, which defines a second-degree polynomial in p_c, admits real roots. Transposing this logic to the present context, we can define the following generic expression:

$$\hat{K}_p\left(s^e, c^e; c_i\right) \equiv \frac{\left(s^e + c^e + 2\sigma - 2c_i\right)^2}{8\left(s^e + 2\sigma\right)},$$

where (s^e, c^e) corresponds to the consumers' expectations and c_i is the realized cost for the entrepreneur. That is, (s^e, c^e) is (s_L, c_L), (s_H, c_H), or $(\bar{s}, \bar{c})$, with $\bar{c} \equiv \lambda c_H + (1-\lambda) c_L$, while c_i belongs to $\{c_L, c_H\}$. Using this definition, we can characterize the type of projects the entrepreneur is able to finance through pre-ordering under either full or asymmetric information. The following lemma summarizes our results.

Lemma 4 *Suppose that the entrepreneur chooses crowdfunding based on* pre-ordering *to finance her project. Under* full information*, the entrepreneur is able to finance high quality if* $K \leq \hat{K}_p\left(s_H, c_H; c_H\right)$ *and low quality if* $K \leq \hat{K}_p\left(s_L, c_L; c_L\right)$.[24] *Under* asymmetric information*, if* $K < \hat{K}_p\left(\bar{s}, \bar{c}; c_H\right)$*, then the PBNE is a pooling equilibrium: both high and low quality can be financed. If* $\hat{K}_p\left(s_L, c_L; c_H\right) \leq K < \hat{K}_p\left(s_L, c_L; c_L\right)$*, then the PBNE is a separating equilibrium: only low quality can be financed. There exists no separating PBNE in which only high quality is financed.*

To assess the effect of information asymmetry, we need to rank the various threshold values. Note that $\hat{K}_p$ increases with s^e and c^e, which implies that $\hat{K}_p\left(s_H, c_H; c_H\right) > \hat{K}_p\left(\bar{s}, \bar{c}; c_H\right) > \hat{K}_p\left(s_L, c_L; c_H\right)$. Note also that $\hat{K}_p$ decreases with c_i; thus, $\hat{K}_p\left(s_L, c_L; c_L\right) > \hat{K}_p\left(s_L, c_L; c_H\right)$. However, it is a priori impossible to rank $\hat{K}_p\left(s_L, c_L; c_L\right)$ relative to the other two thresholds.

Although the thresholds can be ranked in three different ways, we can draw two general lessons. First, when the capital requirement is small enough or large enough,[25] the entrepreneur's choices coincide under full and asymmetric information: either both qualities can be financed or none of them. Second, for intermediate capital requirements, the presence of asymmetric

[24] We recover the result of the previous section by setting $c_L = c_H = 0$ and $s_L = s_H = 1$; then, $\hat{K}_p\left(s_H, c_H; c_H\right) = \hat{K}_p\left(s_L, c_L; c_L\right) = (1 + 2\sigma)/8$, which is indeed the value of $\hat{K}$ in expression (2).

[25] The precise conditions are, respectively, $K < \hat{K}_p\left(s_L, c_L; c_H\right)$ and $K > \max\{\hat{K}_p\left(s_H, c_H; c_H\right), \hat{K}_p\left(s_L, c_L; c_L\right)\}$.

information restricts the entrepreneur's capacity to finance the projects.[26]

Consider now crowdfunding based on **profit-sharing**. In period 2, the entrepreneur faces the following demand function: $D(p) = 1-(p/s^e)$, where s^e is equal to s_L, s_H, or $\bar{s}$ according to the beliefs the individuals hold. For a realization of quality $i \in \{H, L\}$, the profit-maximization price is $p^* = (s^e + c_i)/2$ and the corresponding profit is $\pi^*(s^e; c_i) = (s^e - c_i)^2/(4s^e)$. Replicating the analysis of the previous section (see the details in the Appendix 7.3), we can determine the largest project size that can be financed through profit sharing when consumers hold beliefs (s^e, c^e) and when the actual realization of cost is c_i as follows:

$$\hat{K}_s(s^e, c^e; c_i) = \begin{cases} \pi^*(s^e; c_i) + \frac{(s^e - p^e + \Sigma)^2}{4s^e} & \text{if } \Sigma \leq s^e + p^e - 2\sqrt{s^e p^e}, \\ \pi^*(s^e; c_i) + \Sigma & \text{if } \Sigma > s^e + p^e - 2\sqrt{s^e p^e}, \end{cases}$$

where p^e is the price the individuals expect the entrepreneur to set in period 2 when they hold beliefs (s^e, c^e). As previously, we use this definition to characterize the equilibrium under full and asymmetric information.

Lemma 5 *Suppose that the entrepreneur chooses crowdfunding based on* profit-sharing *to finance the project. Under* full information*, the entrepreneur is able to finance high quality if* $K \leq \hat{K}_s(s_H, c_H; c_H)$ *and low quality if* $K \leq \hat{K}_s(s_L, c_L; c_L)$.[27] *Under* asymmetric information*, if* $K < \hat{K}_s(\bar{s}, \bar{c}; c_H)$*, then the PBNE is a pooling equilibrium: both high and low quality can be financed. If* $\hat{K}_s(s_L, c_L; c_L) \leq K < \hat{K}_s(s_H, c_H; c_H)$ *[if* $\hat{K}_s(s_H, c_H; c_H) \leq K < \hat{K}_s(s_L, c_L; c_L)$*] then the PBNE is a separating equilibrium: the entrepreneur is only able to finance the launch of a high [low] quality product.*

Again, we need to rank the various thresholds to assess the impact of asymmetric information. It is clear that $\hat{K}_s(s_H, c_H; c_H) > \hat{K}_s(\bar{s}, \bar{c}; c_H)$. However, the ranking between $\hat{K}_s(s_L, c_L; c_L)$ and $\hat{K}_s(s_H, c_H; c_H)$ is ambiguous.[28] As in the pre-ordering case, the existence of three possible rankings does not prevent us from drawing two important general results. First, if $\hat{K}_s(\bar{s}, \bar{c}; c_H) < \hat{K}_s(s_L, c_L; c_L)$, there are configurations of parameters for which a PBNE fails to exist in the asymmetric information case.[29] Moreover, it is only for the latter configurations that different results obtain under full information (both qualities can be financed) and asymmetric information (absence of equilibrium). Anywhere else, information has no effect: in both setting,

[26] More precisely, when $\hat{K}_p(s_L, c_L; c_L) < \hat{K}_p(s_H, c_H; c_H)$, there are values of K such that no quality can be financed under asymmetric information whereas high quality can be financed under full information. When $\hat{K}_p(s_L, c_L; c_L) > \hat{K}_p(s_H, c_H; c_H)$, there are values of K for which only the low quality can be financed under asymmetric information whereas both qualities can be financed under full information.

[27] We recover the result of the previous section by setting $c_L = c_H = 0$ and $s_L = s_H = 1$; then $\hat{K}_s(s_H, c_H; c_H) = \hat{K}_s(s_L, c_L; c_L) = 1/4 + (1 + 2\Sigma)^2/16$ if $\Sigma < \frac{3}{2} - \sqrt{2}$ and $1/4 + \Sigma$ otherwise, as in expression (5).

[28] Take, for example, $c_L = 0$, $s_L = 1$, $s_H = 2$, and $0 < c_H < 2$. With $c_H = 0.5$, we have $\hat{K}_s(c_H, s_H) > \hat{K}_s(c_L, s_L)$ for all Σ, while for $c_H = 1$, we have $\hat{K}_s(c_H, s_H) < \hat{K}_s(c_L, s_L)$ for all Σ.

[29] Namely, for $\hat{K}_s(\bar{s}, \bar{c}; c_H) < \min\{\hat{K}_s(s_L, c_L; c_L), \hat{K}_s(s_H, c_H; c_H)\}$.

as the value of K increases, both qualities, then only one quality (high or low), and then none can be financed through profit sharing. Second, if $\hat{K}_s(\bar{s}, \bar{c}; c_H) > \hat{K}_s(s_L, c_L; c_L)$, the presence of asymmetric information may increase the set of projects that can be financed at equilibrium. In particular, for $\hat{K}_s(s_L, c_L; c_L) < K < \hat{K}_s(\bar{s}, \bar{c}; c_H)$, only the high quality can be financed under full information, whereas a pooling equilibrium (in which both qualities can be financed) exists under asymmetric information.

The following proposition unpacks our results about the effects of asymmetric information.

Proposition 2 *Suppose that quality is exogenous and uncertain. Suppose also that the entrepreneur observes the realization of quality but consumers do not before consuming. Compared with a situation of full information (in which consumers also observe the realization of quality), asymmetric information (a) weakly reduces the financial possibilities in the pre-ordering case but (b) increases them in the profit-sharing case.*

The intuition for this result is that the impossibility for consumers to ascertain product quality constrains the entrepreneur more when she tries to screen consumers and induce them to pre-order her product than when she tries to attract investors. Indeed, under profit sharing, crowdfunders/investors care about product quality only insofar as it affects the expected profitability of their investment; their decision to become investors or not follows, otherwise, the same pattern as under symmetric information. In contrast, under pre-ordering, the uncertainty about product quality directly determines the decision to become a crowdfunder or not as it affects utility through consumption (individuals must form expectations about the two prices the entrepreneur sets).

4.2.2 Endogenous quality realization

If the entrepreneur can control the quality of the product, a situation of hidden action emerges, which generates a moral hazard problem. More specifically, it is no longer nature but the entrepreneur herself who chooses between s_L and s_H before deciding which crowdfunding mechanism to adopt and which price(s) to set. Because high quality is more costly to produce and a low-quality entrepreneur can easily mimic a high-quality entrepreneur in the choice of price, asymmetric information is likely to reduce the incentives to provide high quality. A high-quality entrepreneur may then use a signaling device to try to convince consumers that she does indeed produce high quality.

For a signal to be effective, it must be observable by consumers and difficult (or too costly) to mimic by a low-quality entrepreneur. In the present context, one may thus wonder whether the choice of a particular crowdfunding mechanism could be used as a signaling device. Consumers/investors can certainly observe whether pre-ordering or profit sharing is chosen. Thus, the question is: are there situations in which a high-quality entrepreneur would only choose

a particular crowdfunding mechanism? If so, by choosing this mechanism, a producer of high quality would unambiguously be recognized as such.

The following set of conditions accounts for such a situation. On the one hand, if $K > \max\{\hat{K}_p(\bar{s}, \bar{c}; c_H), \hat{K}_p(s_L, c_L; c_L)\}$, neither quality can be financed through pre-ordering. On the other hand, if $\hat{K}_s(s_L, c_L; c_L) < K < \hat{K}_s(s_H, c_H; c_H)$, only the high quality can be financed through profit sharing. If all conditions are met, an entrepreneur who opts for profit sharing would signal that she produces high quality. The following numerical example illustrates such a possibility.

Example 1 *Take* $s_H = 10$, $c_H = 2$, $s_L = 3$, $c_L = 1$, $\lambda = \frac{1}{2}$, $\sigma = \frac{6}{5}$, *and* $\Sigma = \frac{3}{5}$. *Then, we have* $\hat{K}_p(\bar{s}, \bar{c}; c_H) = 0.575$, $\hat{K}_p(s_L, c_L; c_L) = 0.448$, $\hat{K}_s(s_L, c_L; c_L) = 0.933$, *and* $\hat{K}_s(s_H, c_H; c_H) = 2.2$. *Thus, the choice of profit sharing acts as a signal of high quality for values of* K *between* 0.933 *and* 2.2.

A full analysis of the model is required to ascertain whether this situation is part of a PBNE and to characterize other PBNE of the game. This task is beyond the scope of this article.

5 Discussion and implications

In this section, we discuss several issues surrounding crowdfunding that we have not properly addressed so far; we also derive empirical and managerial implications from our theoretical results.

First, in our context, crowdfunding consists of a mix of operating and financing decisions. On the one hand, it is a financing decision, because the entrepreneur needs to raise money for production and thus compares the cost of capital of the different forms of crowdfunding. On the other hand, it is an operating decision, insofar as it affects sales and, thus, production level. In addition, price discrimination occurs under pre-ordering, which also makes crowdfunding an operating decision. In contrast, crowdfunding based on profit sharing is a pure financing decision in our analysis because the operating outcome is the same as under traditional financing.

Second, although we defined the concept of crowdfunding in Section 2, a note on how it differs from other sources of entrepreneurial finance is still warranted. Previous entrepreneurship studies considered consumer financing through pre-ordering part of bootstrap financing (see, e.g., Ebben and Johnson, 2006, who refer to it under the method "obtain advance payments" from customers; however, Winborg and Landstrom, 2001, do not consider this category). Consumer financing can also be called a working capital loan. However, it is considered just one among many other bootstrap techniques and only overlaps with a specific form of crowdfunding: pre-ordering. Thus, these studies generally consider financing by consumers rather narrowly. Conversely, bootstrap finance does not distinguish between advance payments made

at the very beginning of an entrepreneurial initiative and those made during the course of further developments. Crowdfunding pertains specifically to the financing of entrepreneurial initiatives. Similarly, crowdfunding may be viewed as part of the "friends and family (2Fs)" group that also involves unsophisticated investors. However, the definition offered in Section 2 also shows clear differences. One is that the 2Fs have personal links with the entrepreneur, unlike the crowd tapped under crowdfunding.[30] Our approach suggests that crowdfunding should be considered a distinct form of financing that centers on funding from the crowd rather than professional investors (i.e., for whom making risky investments are their business activity) or individuals who have a personal link to the entrepreneur (which is the case for 2Fs).

In Section 2, we briefly mentioned the legal issues related to equity crowdfunding that involve equity issuance. Although the legal requirements in a few countries make it easily possible (see, e.g., Ahlers et al., 2012, for equity crowdfunding practices in Australia), most countries still impose severe constraints. In Europe, equity crowdfunding is generally limited to €100,000 (De Buysere et al., 2012). However, discussions are ongoing in many countries to reform registration requirements for smaller firms that would facilitate crowdfunding initiatives (Griffin, 2012, offers a critical discussion on this debate in the United States). Crucially for our context, these registration constraints only apply to securities issuance, such as equity, and not to other forms of crowdfunding. Moreover, profit-sharing mechanisms do not need to involve securities issuance but can be based on sharing of gains on a contractual basis. This is, for example, the case on Sandawe, in which crowdfunders receive initially 60% of the gains from sales rather than equity. Our model of crowdfunding under profit sharing also enables such form, which means our model outcome is not necessarily constrained by national securities regulations.

Our theoretical analysis offers several empirical and managerial implications, some of which generate testable predictions. Given the nascent nature of crowdfunding research, these predictions may offer guidance for future research agendas. The first set of predictions pertains to Proposition 1. Our model predicts that pre-ordering schemes are more likely when the funding needs of the entrepreneur are low and profit-sharing schemes are more likely when funding needs are high. As mentioned previously, the level of funding should be interpreted relative to market size. If we keep the level of funding needs constant, this implies that pre-ordering is more likely in larger markets and, thus, for products that can reach a large base of costumers. In contrast, products that are very specific in nature and are only of use to a narrow set of consumers (e.g., a comic book or an obscure movie) may be more often funded through a profit-sharing scheme or donations. Moreover, profit-sharing schemes are more often preferred in the presence of information asymmetry, at least in our context. We expect information asymmetry to be more pronounced when the entrepreneur has only a prototype or the project is in an early stage of

[30] Lee and Persson (2012) also argue that a distinctive feature of 2Fs financing is that it creates altruistic ties with the entrepreneur, which may increase entrepreneurial aversion to failure. This stands in sharp contrast with financing by the crowd, which is unknown to the entrepreneur.

development. Focusing on profit-sharing schemes only, our analysis offers predictions about the size of the investor base. An entrepreneur will attempt to attract a larger investor base (i.e., that also includes individuals who do not buy the product) in the event of larger capital needs (unless community benefits are excessively high), leading to larger heterogeneity in the crowdfunders.

Next, our analysis of the choice of crowdfunding approach in the presence of moral hazard about project quality suggests that the profit-sharing approach (including equity crowdfunding) can serve to signal high-quality projects. This raises at least two implications that for further investigation. First, from a policy perspective, our results suggest that securities regulators should push for specific regulation that fosters equity crowdfunding, as currently done in the United States with the Jumpstart Our Business Startups Act. In the absence of effective profit-sharing platforms, entrepreneurs can use pre-ordering mechanisms, which are less regulated but induce entrepreneurs to opt for lower-quality products in the context examined. Second, our results also suggest that the profit-sharing approach is more suitable for early-stage ventures because they are intrinsically more uncertain and because the pre-ordering approach typically requires the existence of a prototype at the time of crowdfunding. This conjecture could be empirically tested by comparing the set of projects proposed on equity-based versus pre-ordering-based platforms.[31]

Finally, from a managerial perspective, entrepreneurs, in setting up their crowdfunding campaign, should build the "right" community of crowdfunders according to their financing and operating needs. In other words, to ensure a viable crowdfunding campaign, entrepreneurs must provide an appropriate environment for the crowdfunders to enjoy sufficient community benefits from their participation. The form and extent of community benefits will determine the type of crowdfunding mechanism the entrepreneur should use. Building a community that supports the entrepreneur is a critical ingredient to make crowdfunding more profitable than traditional funding. In the absence of such non-monetary benefits, price discrimination is not possible, and thus both forms of crowdfunding yield exactly the same outcome as seeking money from a bank or a large equity investor.

6 Concluding remarks

This article sheds light on managerial implications of crowdfunding practices used for entrepreneurial activities. It stresses the need to build a community that ultimately enjoys additional private benefits from participation to make crowdfunding a viable alternative to investor- or creditor-based funding, such as through banks, business angels, or even venture capital. In setting up the initiative, the entrepreneur potentially faces the following tradeoff. Crowdfunding allows for price discrimination. In the case of pre-ordering, the capacity to optimally implement

[31] We thank two anonymous reviewers for suggesting these implications.

price discrimination between pre-ordering consumers (the crowdfunders) and other consumers may, however, be constrained by the amount of capital the entrepreneur needs to raise to cover the up-front (fixed) costs. Whenever this amount exceeds some threshold, the distortion in price discrimination becomes excessive, in which case the profitability of the crowdfunding initiative is reduced. For larger amounts, crowdfunding based on profit sharing or equity issuance becomes more worthwhile for the entrepreneur when community benefits are associated with the decision to finance the entrepreneurial project. This is because larger amounts help the entrepreneur induce more individuals to participate in the financing without affecting the fraction of profits he or she needs to give up to obtain financing. Finally, we offer insights into how quality uncertainty and information asymmetry affect this tradeoff.

To our knowledge, this is the first study to offer a theoretical analysis of crowdfunding. Following Agrawal et al. (2013), this study suggests that economic theory helps explain the recent rise in various forms of crowdfunding. We thus highlight follow-up research questions on the topic. First, further research should examine when crowdfunders can also participate in decisions about product development or even have voting rights on strategic decisions. In this case, control rights and voting power become additional benefits for the participating crowd. Crowdfunding through pre-ordering has very different effects on information and voting results than if the crowd shares profits with the entrepreneur. In addition, outcomes of votes can provide valuable insights into the optimal design of products if the voting community is representative for the overall population of endconsumers.

Second, additional research should connect the topic with the ongoing research on platforms and two-sided markets. Several crowdfunding platforms have emerged recently, such as IndieGoGo, Kickstarter, and RocketHub, similar in spirit to online lending markets (Everett, 2008; Freedman and Jin, 2011; Hildebrand et al., 2013). These platforms intermediate between entrepreneurs and potential crowdfunders, creating a two-sided market.[32] Understanding of the role of crowdfunding platforms is still limited; thus, research could investigate the extent to which platforms increase the chances of success of crowdfunding initiatives or solve asymmetric information issues. For example, for crowdfunders, platforms could facilitate learning of product quality through interactions with other crowdfunders or by observing others' contributions. Also worthwhile would be to integrate learning processes in crowdfunding dynamics and choices of crowdfunding mechanisms. For example, Gerber et al. (2012) suggest that several forms of entrepreneurial learning from the crowd takes place through the crowdfunding process, making such learning a crucial feature of crowdfunding. In addition, research could examine peer effects on crowdfunding platforms, as suggested by Ward and Ramachandran (2010).

One limitation of our analysis is that we considered the two approaches of crowdfunding

[32]See, most notably, Eisenmann et al. (2006, 2011) and Zhu and Iansiti (2012) in the strategic management literature; see also Belleflamme and Peitz (2010, Chapter 22) for a textbook treatment of the industrial organization aspects.

mutually exclusive. In reality, however, entrepreneurs may seek financing simultaneously on various platforms and, thereby, combine the two approaches. An important direction for future modeling would then be to allow entrepreneurs to choose the optimal mix between equity-based and reward-based crowdfunding. Such modeling would raise several challenges because individuals would now contemplate a larger set of choices (e.g., whether to pre-order or not, whether to contribute directly to the financing or not) and because the relative attractiveness of these choices would endogenously depend on how much money the entrepreneur chose to raise with each crowdfunding form. Another limitation is that we assume that individuals know the distribution of community benefits for the others in the crowd and are fully rational; they can thus solve for the subgame-perfect equilibrium of the game and act accordingly. Although such assumption is common in settings with interdependent utility functions (e.g., in the presence of network effects; see, e.g., Katz and Shapiro, 1985), research could examine what would happen if individuals were endowed with less information and/or farsightedness.

Future work could also explore entrepreneurs' information motivations. Indeed, although the primary goal of crowdfunding is to raise money, it can also help firms test, promote, and market their products; gain a better knowledge of their consumers' tastes; or create new products or services altogether. In this sense, crowdfunding can be used as a promotion device, as a means to support mass customization or user-based innovation, or as a way for the producer to gain better knowledge of its consumers' preferences. In other cases, it is a unique way to validate original ideas in front of a specifically targeted audience. In turn, crowdfunding can provide insights into the market potential of product or service.

7 Appendix

7.1 Proof of Lemmata 2 and 3

The entrepreneur can attract either a large or a small base of investors. We consider the two options in turn.

1. Large base of crowdfunders. In the first option, the entrepreneur chooses the lowest α that satisfies the incentive constraint (4):

$$\alpha_{(1)} = 4K - 4n_c\Sigma.$$

She then chooses n_c to maximize her residual profit, which is equal to $\Pi = \left(1 - \alpha_{(1)}\right)(1/4)$, subject to $0 \leq \alpha_{(1)} < 1$.[33] We can easily show that the residual profit increases with n_c (because $\alpha_{(1)}$ decreases with n_c). The unconstrained optimum is then to set $n_c = 1$. The corresponding share of distributed profit is then equal to $\alpha_{(1)} = 4\left(K - \Sigma\right)$.

There are three possible cases. First, if $K \geq 1/4 + \Sigma$, the entrepreneur is not able to make positive profits (as $\alpha_{(1)} \geq 1$). Second, if $\Sigma < K < 1/4 + \Sigma$, we have an interior solution because the unconstrained share of distributed profits is strictly positive and less than unity; in that

[33] The entrepreneur receives K/n_c from each of the n_c crowdfunders, which exactly covers her capital requirement K.

case, all individuals become investors ($n_c = 1$). Finally, if $K \leq \Sigma$, we have a corner solution with $\alpha_{(1)} = 0$. Here, the capital requirement is so small that the entrepreneur does not need to distribute profits: community benefits are sufficient to motivate investors. In this case, the number of crowdfunders is such that $\alpha_{(1)} = 0$ (ii.e., $n_c = K/\Sigma$). This implies that crowdfunders do not expect any financial rewards from their investment. As mentioned previously, this situation corresponds to crowdfunders providing donations rather than participating in the profits of the firm. This is consistent with empirical facts that some platforms specialize in intermediating between firms and crowdfunders for donations. In this instance, the benefits in terms of utility are the community benefits accruing from making production possible. The difference with existing literature on donations (e.g., Glaeser and Shleifer, 2001) is that, here, donors are consumers rather than altruistic individuals.

With the previous results, we can express the entrepreneur's residual profits in the first option as follows:

$$\Pi_{(1)} = \begin{cases} \frac{1}{4} & \text{if } 0 \leq K \leq \Sigma, \\ \frac{1}{4} - (K - \Sigma) & \text{if } \Sigma < K \leq \frac{1}{4} + \Sigma, \\ 0 & \text{if } K > \frac{1}{4} + \Sigma. \end{cases} \tag{6}$$

2. Small base of crowdfunders. In the second option, crowdfunders are such that $\theta \geq \theta_i$. Therefore $n_c = 1 - \theta_i$. Using expression (3) and solving for α, we find that

$$\alpha_{(2)} = 2\left(2n_c^2 - n_c\left(1 + 2\Sigma\right) + 2K\right).$$

The entrepreneur sets n_c to maximize $\Pi = \left(1 - \alpha_{(2)}\right)(1/4)$, subject to (a) $n_c \leq 1/2$ (as crowdfunders must belong to the set of consumers) and (b) $\alpha_{(2)} \geq 0$.[34] As $\partial\alpha_{(2)}/\partial n_c = 8n_c - 2\left(1 + 2\Sigma\right)$, the unconstrained optimum becomes as

$$n_c^* = \frac{1}{4}\left(1 + 2\Sigma\right).$$

This value satisfies constraint (a) as long as $\Sigma \leq 1/2$. Computing the corresponding value of $\alpha_{(2)}$, we find

$$\alpha_{(2)}^* = \frac{1}{4}\left(16K - \left(1 + 2\Sigma\right)^2\right).$$

Thus, constraint (b) is satisfied as long as $K \geq \left(1 + 2\Sigma\right)^2/16$. For this low level of profit-sharing $\alpha_{(2)}^*$, only consumers with the highest θ will be willing to become investors. Crucially, under $\alpha_{(2)}^*$, we obtain a level of n_c^* such that all the consumers for which the incentive constraint holds need to invest to ensure sufficient financing for the firm. Any deviation would lead to project stoppage. Thus, consumers are all pivotal, which in turn explains why investors rationally set their outside option equal to zero (as assumed previously).

Four cases are possible depending on the values of Σ and K:

	$K > \frac{(1+2\Sigma)^2}{16}$	$K \leq \frac{(1+2\Sigma)^2}{16}$
$\Sigma < \frac{1}{2}$	(A)	(C)
$\Sigma \geq \frac{1}{2}$	(B)	(D)

A. We have an interior solution: the number of crowdfunders is n_c^* and the share of distributed profit is $\alpha_{(2)}^*$; we compute the corresponding residual profit for the entrepreneur as $\Pi_{(A)} = \frac{1}{4} + \frac{(1+2\Sigma)^2}{16} - K$.

[34] It is clear that the entrepreneur will optimally choose $\alpha < 1$ because she can always refrain from launching her project and make zero profits.

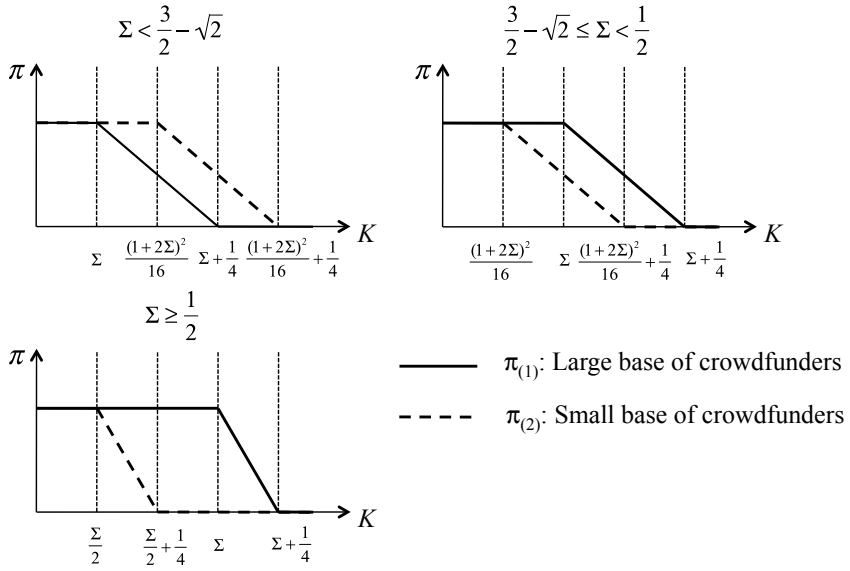

Figure 4: Large base or small base of crowdfunders under profit sharing

B. The first constraint is violated and the entrepreneur chooses $n_c = 1/2$; the share of distributed profit is then given by $2(2K - \Sigma)$, and the entrepreneur's residual profit is $\Pi_{(B)} = \frac{1}{4} + \frac{\Sigma}{2} - K$.

C. The second constraint is violated, and n_c is chosen so that $\alpha_{(2)} = 2\left(2n_c^2 - n_c(1 + 2\Sigma) + 2K\right) = 0$. Let $\hat{n}_c$ denote the smallest root of this polynomial. We can show that $\Sigma < 1/2$ implies $\hat{n}_c < 1/2$. As under the first option, the low capital requirement allows the entrepreneur to collect K without having to distribute any profit; crowdfunders are thus donors in this case. Therefore, $\Pi_{(C)} = 1/4$.

D. Here, two sub-cases must be distinguished. If $K < \Sigma/2$, then $\hat{n}_c < 1/2$. Thus, the entrepreneur can set $\alpha_{(2)} = 0$ and earns $\Pi_{(C)}$. Otherwise, for $\Sigma/2 \le K \le (1 + 2\Sigma)^2/16$, the entrepreneur sets $n_c = 1/2$ and earns $\Pi_{(B)}$.

In summary, we can express the entrepreneur's residual profit in the second option as follows:

$$\Pi_{(2)} = \begin{cases} \frac{1}{4} & \text{if } K \le \frac{(1+2\Sigma)^2}{16} \text{ and } \Sigma < \frac{1}{2} \text{ or } K < \frac{\Sigma}{2} \text{ and } \Sigma \ge \frac{1}{2}, \\ \frac{1}{4} - \left(K - \frac{(1+2\Sigma)^2}{16}\right) & \text{if } K \in \left[\frac{(1+2\Sigma)^2}{16}, \frac{1}{4} + \frac{(1+2\Sigma)^2}{16}\right] \text{ and } \Sigma \le \frac{1}{2}, \\ \frac{1}{4} - \left(K - \frac{\Sigma}{2}\right) & \text{if } K \in \left[\frac{\Sigma}{2}, \frac{1}{4} + \frac{\Sigma}{2}\right] \text{ and } \Sigma \ge \frac{1}{2}, \\ 0 & \text{otherwise.} \end{cases} \tag{7}$$

To determine the entrepreneur's best conduct in period 1, we now need to compare expressions (6) and (7) and to identify the best option for each combination of parameters. To ease the comparison, we superimpose the two profit functions in Figure 4.

Three cases must be distinguished (corresponding to the three panels of Figure 4). Note first that in all cases, there are two situations in which the entrepreneur is indifferent between the two options. On the one hand, if the capital to be raised is fairly small, the entrepreneur does

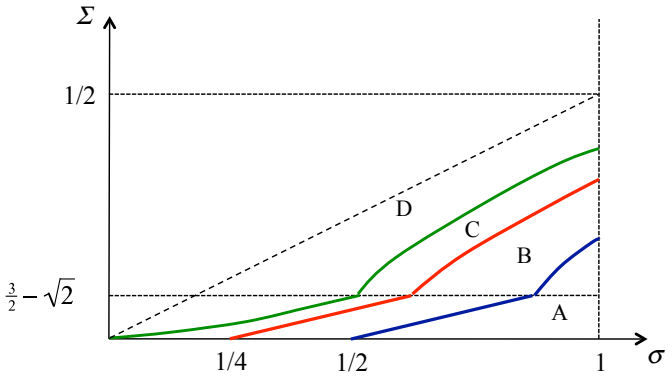

Figure 5: Choice of crowdfunding mechanism

not need to distribute any profit regardless of whether she attracts a large or a small base of "crowdfunders/donors" ($\pi_{(1)} = \pi_{(2)} = 1/4$). On the other hand, if the capital to be raised is fairly large, the entrepreneur cannot finance her venture under any profit-sharing option ($\pi_{(1)} = \pi_{(2)} = 0$). For intermediary values of K, the option of attracting a large base of crowdfunders dominates unless community benefits are relatively unimportant (i.e., $\Sigma < 3/2 - \sqrt{2}$).

The profit function of Lemma 3 is straigthforwardly derived from Figure 3.

7.2 Proof of Proposition 1

The proof is based on Figure 3. Recall that to cover all potential scenarios, we have deliberately chosen to represent the pre-ordering profit Π_p for a large value of σ, namely $\sigma > 1/2$. We have then drawn the profit-sharing profit Π_s for increasing values of Σ, namely $0 < \Sigma_1 < \Sigma_2 < \Sigma_3 < \Sigma_4$. Each of these values belongs to one of four possible configurations of parameters, whose exact outlines we depict in Figure 5.

Area A. For Σ close to zero (e.g., Σ_1 in Figure 3), pre-ordering dominates profit sharing for any $K \geq 0$. This is because if profit sharing becomes unprofitable for a smaller value of K than so does pre-ordering; that is, if $1/4 + f(\Sigma) < (1 + 2\sigma)/8$, where we recall from expression (5) that $f(\Sigma) = (1 + 2\Sigma)^2/16$ for $\Sigma < \frac{3}{2} - \sqrt{2}$ and $f(\Sigma) = \Sigma$ otherwise. Developing the latter inequality, we have $f(\Sigma) < (2\sigma - 1)/8$, which is only possible if $\sigma > 1/2$.

As Σ increases, profit sharing starts dominating pre-ordering after K goes beyond some threshold. Let K_{ps} denote this threshold. As the graph in Figure 5 shows, K_{ps} can take on three different values.

Area B. For small values of Σ (e.g., Σ_2 in Figure 3), Π_p "cuts" Π_s when the latter function jumps from a positive value to zero, that is, for $K = (1 + 2\sigma)/8$. Thus, $K_{ps} = (1 + 2\sigma)/8$ in this case, which occurs for (σ, Σ), such that $(2\sigma - 1)/8 < f(\Sigma) < (4\sigma - 1)/16$; we note that a necessary condition for this case to exist is $\sigma > 1/4$.

Area C. For intermediate values of Σ (e.g., Σ_3 in Figure 3), Π_p and Π_s intersect in their respective middle sections; thus, K_{ps} is the value of K that solves $(1/16)\left(1 + \sqrt{1 - 8K/(1 + 2\sigma)}\right)^2 = 1/4 + f(\Sigma) - K$. This case occurs for (σ, Σ), such that $(4\sigma - 1)/16 < f(\Sigma) < \sigma^2/(1 + 4\sigma)$.

Area D. For large values of Σ (e.g., Σ_4 in Figure 3), Π_p and Π_s intersect in their respective top sections; we can then easily show that $K_{ps} = \sigma^2/(1+4\sigma)$; this occurs for $f(\Sigma) > \sigma^2/(1+4\sigma)$.

For Corallary 1, the equation $\Sigma = \sigma/2$ is represented by the dashed line in Figure 3. We show that this line is completely included in Area D, which proves the result.

7.3 Asymmetric information

In this appendix, we develop the model with asymmetric information and exogenous quality of Subsection 4.2.1.

7.3.1 Proof of Lemma 4

In period 2, consumers with values of θ below θ_c decide to buy the product iff $\theta s^e - p_r \geq 0$, or $\theta \geq p_r/s^e$, where s^e is equal to s_L, s_H, or $\bar{s}$ according to the beliefs they hold. Thus, the entrepreneur's program at period 2 becomes $\max_{p_r}(p_r - c_i)(\theta_c - p_r/s^e)$, where $i = H, L$ according to the realization of quality. The optimal price and second-period profit are then

$$p_r(\theta_c, i) = \tfrac{1}{2}(\theta_c s^e + c_i) \text{ and } \pi_2(\theta_c, i) = \tfrac{1}{4s^e}(\theta_c s^e - c_i)^2.$$

In period 1, the indifferent consumer between pre-ordering and not is identified by θ_c, such that $\theta_c(s^e + \sigma) - p_c = \theta_c s^e - p_r^e$ or $\theta_c = (p_c - p_r^e)/\sigma$, where p_r^e denotes the expected second-period price.[35] We examine different systems of beliefs in turn.

First, suppose that *consumers believe that both qualities are produced.* Then $s^e = \bar{s}$ and

$$\begin{aligned} p_r^e &= \lambda\tfrac{1}{2}(\theta_c\bar{s} + c_H) + (1-\lambda)\tfrac{1}{2}(\theta_c\bar{s} + c_L) \\ &= \tfrac{1}{2}(\theta_c\bar{s} + \bar{c}) \text{ with } \bar{c} = \lambda c_H + (1-\lambda)c_L. \end{aligned}$$

It follows that

$$\theta_c = \frac{1}{\sigma}\left(p_c - \tfrac{1}{2}(\theta_c\bar{s} + \bar{c})\right) \Leftrightarrow \theta_c = \frac{2p_c - \bar{c}}{\bar{s} + 2\sigma}.$$

We can then write the entrepreneur's objective as follows (with $c_i = c_H$ or c_L according to the realization of quality):

$$\max_{p_c}(p_c - c_i)\left(1 - \frac{2p_c - \bar{c}}{\bar{s} + 2\sigma}\right) + \tfrac{1}{4\bar{s}}\left(\frac{2p_c - \bar{c}}{\bar{s} + 2\sigma}\bar{s} - c_i\right)^2$$

$$\text{s.t. } p_c\left(1 - \frac{2p_c - \bar{c}}{\bar{s} + 2\sigma}\right) \geq K \text{ and } 0 \leq \frac{2p_c - \bar{c}}{\bar{s} + 2\sigma} \leq 1.$$

It is clear that the profit function decreases with c_i. Thus, the entrepreneur always makes a higher profit if quality turns out to be low rather than high. To have a PBNE (i.e., for the consumers' beliefs to be consistent with the entrepreneur's conduct), we thus must check that a high-quality entrepreneur finds it profitable to launch the product. Extending the analysis of the previous section, we compute the upper bound on what can be financed through pre-ordering as the largest K, such that there is a price p_c where $(p_c - c_H)(1 - \theta_c) = K$, that is, the following

[35] We assume here that all consumers – in period 1 and in period 2 – hold the same beliefs. This suggests that there is no revelation of information from crowdfunding behavior.

polynomial has real roots:[36]

$$2p_c^2 - (\bar{s} + 2\sigma + \bar{c} + 2c_H)\, p_c + (\bar{s} + 2\sigma)\, K + (\bar{s} + 2\sigma + \bar{c})\, c_H = 0.$$

It does so as long as

$$K \leq \frac{(\bar{s} + \bar{c} + 2\sigma - 2c_H)^2}{8(\bar{s} + 2\sigma)} \equiv \hat{K}_p(\bar{s}, \bar{c}; c_H).$$

Second, suppose that *consumers believe that only quality j is produced*. In this case, $s^e = s_j$, $p_r^e = \frac{1}{2}(\theta_c s_j + c_j)$, and we can confirm that $\theta_c = (2p_c - c_j)/(s_j + 2\sigma)$. Consequently, the entrepreneur's profit function is

$$\Pi(c_i) = (p_c - c_i)\left(1 - \frac{2p_c - c_j}{s_j + 2\sigma}\right) + \tfrac{1}{4s_j}(\theta_c s_j - c_i)^2 - K,$$

which decreases with c_i. It follows that whatever the consumers' beliefs ($j = H$ or L), $\Pi(c_L) > \Pi(c_H)$. That is, for given consumers' beliefs, if an entrepreneur with high quality is able to finance her venture, so is an entrepreneur with low quality. Therefore, $s^e = s_H$ cannot form consistent beliefs (as it would require that only the high-quality entrepreneur finds it profitable to enter the market). Consider then $s^e = s_L$. The upper bound on what can be financed is the largest K, such that the following polynomial has real roots:

$$(p_c - c_i)\left(1 - \frac{2p_c - c_L}{s_L + 2\sigma}\right) = K.$$

That is,

$$K \leq \frac{(s_L + c_L + 2\sigma - 2c_i)^2}{8(s_L + 2\sigma)} \equiv \hat{K}_p(s_L, c_L; c_i).$$

For the beliefs $s^e = s_L$ to be consistent, we need only that an entrepreneur with low quality is able to finance her venture: $\hat{K}_p(s_L, c_L; c_H) < K \leq \hat{K}_p(s_L, c_L; c_L)$ or

$$\frac{(s_L + c_L + 2\sigma - 2c_H)^2}{8(s_L + 2\sigma)} < K \leq \frac{(s_L + 2\sigma - c_L)^2}{8(s_L + 2\sigma)}.$$

We summarize our result as follows:

- If $K < \hat{K}_p(\bar{s}, \bar{c}; c_H)$, the PBNE is a *pooling* equilibrium: the entrepreneur is able to finance the launch of high- and low-quality products through crowdfunding based on pre-ordering.
- If $\hat{K}_p(s_L, c_L; c_H) \leq K < \hat{K}_p(s_L, c_L; c_L)$, the PBNE is a *separating* equilibrium: the entrepreneur is only able to finance the launch of a low-quality product. The entrepreneur is not able to finance any quality at the PBNE if $K > \max\{\hat{K}_p(\bar{s}, \bar{c}; c_H), \hat{K}_p(s_L, c_L; c_L)\}$.

We can easily establish that $\hat{K}_p(\bar{s}, \bar{c}; c_H) > \hat{K}_p(s_L, c_L; c_H)$. However, we are not able to rank $\hat{K}_p(\bar{s}, \bar{c}; c_H)$ and $\hat{K}_p(s_L, c_L; c_L)$; however, $\hat{K}_p(s_L, c_L; c_L) > \hat{K}_p(\bar{s}, \bar{c}; c_H)$ is more likely to be satisfied the larger $(c_H - c_L)$ and the smaller λ. In any case, there is a region of parameters ($\hat{K}_p(s_L, c_L; c_H) < K < \min\{\hat{K}_p(\bar{s}, \bar{c}; c_H), \hat{K}_p(s_L, c_L; c_L)\}$) in which the pooling and separating equilibria coexist. We can also confirm that a PBNE exists for all parameters.

[36] We consider that the revenues from pre-ordering, $p_c(1 - \theta_c)$, must cover not only the fixed cost K but also the variable cost $c_H(1 - \theta_c)$. That is, we do not allow the entrepreneur to incur losses in the first period (even if these losses can be recouped through positive profits in the second period).

If there were perfect information, high quality could be financed for $K \leq \hat{K}_p(s_H, c_H; c_H)$, and low quality for $\hat{K}_p(s_L, c_L; c_L)$.

7.3.2 Proof of Lemma 5

In period 2, the entrepreneur faces the following demand function: $D(p) = 1 - (p/s^e)$, where s^e is equal to s_L, s_H, or $\bar{s}$ according to the beliefs of the individuals. For a realization of quality $i \in \{H, L\}$, the profit-maximization price is $p^* = (s^e + c_i)/2$ and the corresponding profit is

$$\pi^* = \frac{(s^e - c_i)^2}{4s^e}.$$

In period 1, when deciding to become investors or not, individuals need to anticipate the future equilibrium price (p^e) and profit (π^e). At price p^e, only individuals with $\theta \in [p^e/s^e, 1]$ buy the product. The incentive constraints for investment in the first period are thus

$$\begin{cases} \theta s^e - p^e + V \geq 0 & \text{if } \theta \in [p^e/s^e, 1], \\ V \geq 0 & \text{if } \theta \in [0, p^e/s^e], \end{cases} \text{ with } V \equiv \frac{\alpha}{n_c}\pi^e - \frac{K}{n_c} + \Sigma.$$

As in Section 3, the entrepreneur can choose between two options: either set α so that $V \geq 0$ and attract a large base of crowdfunders, or set α so that $V < 0$ and focus on a small base of crowdfunders made up of future buyers of the product.

In the *first option*, the entrepreneur chooses the lowest α that satisfies $V = 0$: $\alpha_{(1)} = (K - n_c\Sigma)/\pi^e$. She then chooses n_c to maximize her residual profit, which is equal to $\Pi = \left(1 - \alpha_{(1)}\right)\pi^*$, subject to $0 \leq \alpha_{(1)} < 1$. We can easily show that the residual profit increases with n_c (because $\alpha_{(1)}$ decreases with n_c). The unconstrained optimum is then to set $n_c = 1$. The corresponding share of distributed profit is then equal to $\alpha_{(1)} = (K - \Sigma)/\pi^e$. As previously, there are three possible cases: (a) if $K \geq \pi^e + \Sigma$, then $\alpha_{(1)} \geq 1$ and $\Pi_{(1)} = 0$; (b) if $\Sigma < K < \pi^e + \Sigma$, then $0 < \alpha_{(1)} < 0$, $n_c = 1$, and $\Pi_{(1)} = \pi^*\left(1 - \frac{K-\Sigma}{\pi^e}\right)$; and (c) if $K \leq \Sigma$, $\alpha_{(1)} = 0$, $n_c = K/\Sigma$, and $\Pi_{(1)} = \pi^*$.

In the *second option*, crowdfunders are such that $\theta s^e - p^e + V \geq 0$, or

$$\theta \geq \theta_i \equiv \frac{1}{s^e}(p^e - V) = \frac{1}{s^e}\left(p^e - \left(\frac{\alpha}{n_c}\pi^e - \frac{K}{n_c} + \Sigma\right)\right).$$

Thus, $n_c = 1 - \theta_i$. Solving the latter equation for α, we find

$$\alpha_{(2)} = \frac{1}{\pi^e}\left(s^e n_c^2 - (s^e - p^e + \Sigma)\, n_c + K\right).$$

The entrepreneur sets n_c to maximize $\Pi = \left(1 - \alpha_{(2)}\right)\pi^*$, subject to (a) $n_c \leq 1 - p^e/s^e$ (because crowdfunders must belong to the set of consumers) and (b) $\alpha_{(2)} \geq 0$.[37] As $\partial\alpha_{(2)}/\partial n_c = (2s^e n_c - (s^e - p^e + \Sigma))/\pi^e$, the unconstrained optimum is

$$n_c^* = \frac{1}{2s^e}(s^e - p^e + \Sigma).$$

This value satisfies constraint (a) as long as $\Sigma \leq s^e - p^e$. Computing the corresponding value

[37] It is clear that the entrepreneur will optimally choose $\alpha < 1$ because she can always refrain from launching her project and make zero profits.

of $\alpha_{(2)}$, we find that

$$\alpha^*_{(2)} = \frac{1}{4s^e\pi^e}\left(4s^eK - \left(s^e - p^e + \Sigma\right)^2\right).$$

Thus, constraint (b) is satisfied as long as $K \geq \left(s^e - p^e + \Sigma\right)^2 / 4s^e$. We thus must distinguish among the four following cases:

	$K > \frac{(s^e-p^e+\Sigma)^2}{4s^e}$	$K \leq \frac{(s^e-p^e+\Sigma)^2}{4s^e}$
$\Sigma < s^e - p^e$	(A)	(C)
$\Sigma \geq s^e - p^e$	(B)	(D)

A We have an interior solution: the number of crowdfunders is n^*_c and the share of distributed profit is $\alpha^*_{(2)}$; we compute the corresponding residual profit for the entrepreneur as $\Pi_{(A)} = \pi^*\left(1 - \frac{1}{\pi^e}\left(K - \frac{(s^e-p^e+\Sigma)^2}{4s^e}\right)\right)$.

B The first constraint is violated; the entrepreneur chooses $n_c = 1 - p^e/s^e$; the share of distributed profit is then given by $\left(s^eK - \left(s^e - p^e\right)\Sigma\right) / \left(s\pi^e\right)$, and the entrepreneur's residual profit is $\Pi_{(B)} = \pi^*\left(1 - \frac{1}{\pi^e}\left(K - \frac{(s^e-p^e)\Sigma}{s^e}\right)\right)$.

C The second constraint is violated; n_c is chosen so that $\alpha_{(2)} = \frac{1}{\pi^e}\left(s^en_c^2 - \left(s^e - p^e + \Sigma\right)n_c + K\right) = 0$. Let $\hat{n}_c$ denote the smallest root of this polynomial. We can show that $\Sigma < s^e - p^e$ implies $\hat{n}_c < 1 - p^e/s^e$. As with the first option, the low capital requirement allows the entrepreneur to collect K without having to distribute any profit. Thus, $\Pi_{(C)} = \pi^*$.

D Here, two sub-cases must be distinguished. If $K < \left(s^e - p^e\right)\Sigma/s^e$, then $\hat{n}_c < 1 - p^e/s^e$. Thus, the entrepreneur can set $\alpha_{(2)} = 0$ and earns $\Pi_{(C)}$. Otherwise, for $\left(s^e - p^e\right)\Sigma/s^e \leq K \leq \left(s^e - p^e + \Sigma\right)^2 / \left(4s^e\right)$, the entrepreneur sets $n_c = 1 - p^e/s^e$ and earns $\Pi_{(B)}$.

In summary, we can express the entrepreneur's residual profit in the second option as follows:

$$\Pi_{(2)} = \begin{cases} \pi^* & \text{if } K \leq \frac{(s^e-p^e+\Sigma)^2}{4s^e} \text{ and } \Sigma < s^e - p^e \\ & \text{or } K \leq \frac{s^e-p^e}{s^e}\Sigma \text{ and } \Sigma \geq s^e - p^e \\ \pi^*\left(1 - \frac{1}{\pi^e}\left(K - \frac{(s^e-p^e+\Sigma)^2}{4s^e}\right)\right) & \text{if } K \in \left[\frac{(s^e-p^e+\Sigma)^2}{4s^e}, \pi^* + \frac{(s^e-p^e+\Sigma)^2}{4s^e}\right] \text{ and } \Sigma \leq s^e - p^e, \\ \pi^*\left(1 - \frac{1}{\pi^e}\left(K - \frac{s^e-p^e}{s^e}\Sigma\right)\right) & \text{if } K \in \left[\frac{s^e-p^e}{s^e}\Sigma, \pi^* + \frac{s^e-p^e}{s^e}\Sigma\right] \text{ and } \Sigma \geq s^e - p^e, \\ 0 & \text{otherwise.} \end{cases}$$

Comparing the two options for each combination of parameters, we find that the entrepreneur's (residual) profit under crowdfunding/profit-sharing is equal to

$$\Pi_s = \begin{cases} \pi^* & \text{if } 0 \leq K \leq f\left(\Sigma\right), \\ \pi^*\left(1 - \frac{1}{\pi^e}\left(K - f\left(\Sigma\right)\right)\right) & \text{if } f\left(\Sigma\right) \leq K \leq \pi^* + f\left(\Sigma\right), \\ 0 & \text{if } K \geq \pi^* + f\left(\Sigma\right). \end{cases}$$

$$\text{with } f\left(\Sigma\right) = \Sigma \text{ for } \Sigma > s^e + p^e - 2\sqrt{s^ep^e} \text{ and } f\left(\Sigma\right) = \frac{(s^e-p^e+\Sigma)^2}{4s^e} \text{ otherwise.}$$

Thus, the largest venture size that can be financed through profit-sharing, $\hat{K}_s$, is given by $\pi^* + f\left(\Sigma\right)$, that is

$$\hat{K}_s\left(c_i, s^e\right) = \begin{cases} \pi^*\left(c_i\right) + \frac{(s^e-p^e+\Sigma)^2}{4s^e} & \text{if } \Sigma \leq s^e + p^e - 2\sqrt{s^ep^e}, \\ \pi^*\left(c_i\right) + \Sigma & \text{if } \Sigma > s^e + p^e - 2\sqrt{s^ep^e}. \end{cases}$$

Individuals' expectations about second-period price and profit depend on their beliefs. If they believe that both qualities will be produced, then $s^e = \bar{s}$ and $p^e = (\bar{s} + \bar{c})/2$. For these beliefs to be consistent, the entrepreneur must find it profitable to produce both quantities. Because $\pi^*(c_H) < \pi^*(c_L)$, the condition is $K \leq \hat{K}_s(c_H, \bar{s})$. In contrast, if individuals believe that only quality i will be produced, then $s^e = s_i$ and $p_e = (s_i + c_i)/2$. For beliefs $s^e = s_H$ to be consistent, we need $\hat{K}_s(c_L, s_L) < K < \hat{K}_s(c_H, s_H)$; for beliefs $s^e = s_L$ to be consistent, we need $\hat{K}_s(c_H, s_H) < K < \hat{K}_s(c_L, s_L)$. Numerical simulations reveal that both cases are possible. For example, consider $c_L = 0$, $s_L = 1$, $s_H = 2$, and $0 < c_H < 2$. With $c_H = 0.5$, we have $\hat{K}_s(c_H, s_H) > \hat{K}_s(c_L, s_L)$ for all Σ, while for $c_H = 1$, we have $\hat{K}_s(c_H, s_H) < \hat{K}_s(c_L, s_L)$ for all Σ.

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