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# Product and Pricing Decisions in Crowdfunding

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This paper studies the optimal product and pricing decisions in a crowdfunding mechanism by which a project between a creator and many buyers will be realized only if the total funds committed by the buyers reach a specified goal. When the buyers are sufficiently heterogeneous in their product valuations, the creator should offer a line of products with different levels of product quality. Compared to the traditional situation where orders are placed and fulfilled individually, with the crowdfunding mechanism, a product line is more likely than a single product to be optimal and the quality gap between products is smaller. This paper also shows the effect of the crowdfunding mechanism on pricing dynamics over time. Together, these results underscore the substantial influence of the emerging crowdfunding mechanisms on common marketing decisions.

**Keywords:** crowdfunding; product line design; price discrimination

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*Many hands make light work.*

—ENGLISH PROVERB

## 1. Introduction

Cristian Barnett is a professional photographer living in Cambridge, England. Mr. Barnett was so fascinated with the Arctic Circle that in 2006 he started visiting the countries intersected by the circle. After seven years and a dozen trips to that area, he decided to create a book called *Life on the Line*, which would contain a selection of portraits he had taken over the years. To raise funds to pay for the design and printing of the books, Mr. Barnett launched the Life on the Line project on Kickstarter on November 26, 2013 (see Figure 1). The funding period would expire on December 31, 2013, with a goal of £10,000. Every buyer who committed £30 or more would receive a signed copy of the book. A buyer who committed £150 or more would receive a collector's edition of the book, hardbound and in a slipcase, and signed with the author's personal dedication. Of course, the pledges would not be redeemed and the books would not be delivered unless the project reached the goal.

Kickstarter is one of the leading online nonequity crowdfunding sites that match people (the “crowd”) with projects. In such crowdfunding sites, creators raise funds from potential buyers to start their ventures. In return the creators offer products to the buyers.<sup>1</sup> The creators are entrepreneurs like Cristian

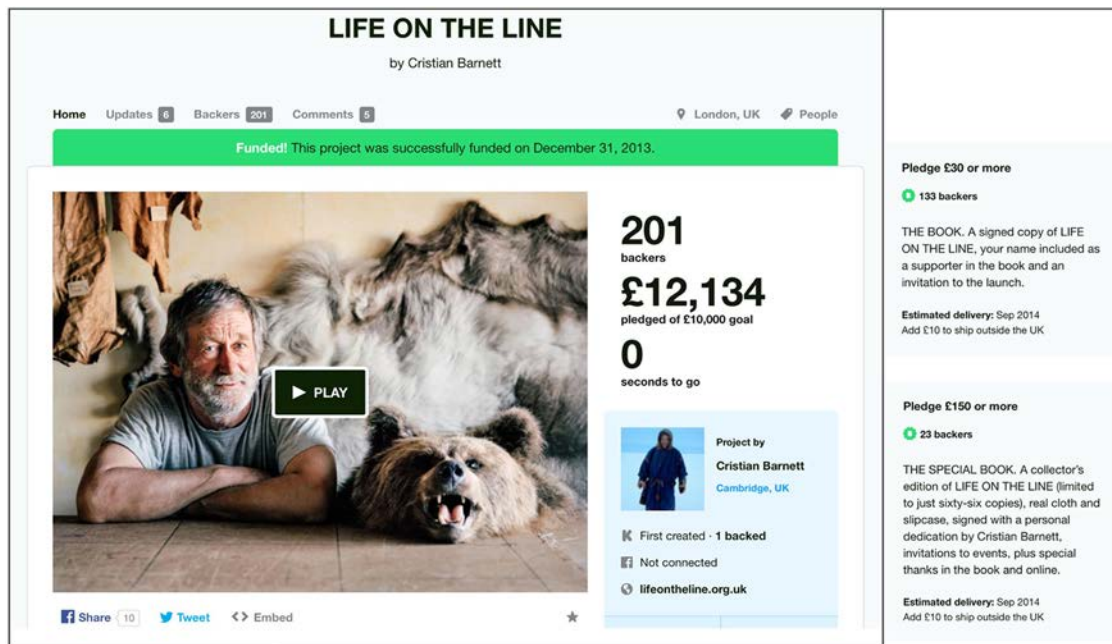
Barnett who may be designers, musicians, software developers or any kind of inventor. Unlike the conventional retail setting, here a buyer not only commits to purchasing the product but also prepays to fund the project. A project will be successfully funded only if the total value of committed purchases exceeds a specified goal within a certain time.<sup>2</sup> Recently the crowdfunding industry has experienced tremendous growth. For example, since its inception in 2009 Kickstarter has raised more than \$800 million and supported more than 50,000 projects. With the passing in the United States of the Jumpstart Our Business Startups Act in September 2013, the crowdfunding industry acquired legitimacy and is expected to lead a new era of entrepreneurship (Wortham 2013).

In this paper we investigate crowdfunding product and pricing decisions. Creators often provide a line of products for buyers to choose from. Cristian Barnett, for example, offered multiple versions of his *Life on the Line* book, including a signed copy for £30 and a collector's edition for £150. We monitored all of the projects posted on Kickstarter between November 14–18, 2013. Among 457 newly launched projects, 448 (98%) offered more than one level of rewards and prices. A seller may design a menu of offerings (with different qualities or in different quantities) when buyers have heterogeneous valuations (Moorthy 1984, Monahan 1984). A crucial consideration in menu design is incentive compatibility;

<sup>1</sup> In equity crowdfunding sites, funders are also investors for the creators' financial endeavors (Agrawal et al. 2014). This paper focuses on nonequity crowdfunding where buyers are also funders but not investors.

<sup>2</sup> One reason that creators seek the crowdfunding platform is that private equity investors or venture capitalists seldom back entrepreneurs who are unable to show evidence of substantial sales. See, e.g., Cortese (2013).

Figure 1 (Color online) “Life on the Line” Project on Kickstarter



Source. Used with permission from Cristian Barnett.

each type of consumer should be better off choosing the option designed for them rather than any other option. Following the same logic, a creator may provide a menu of crowdfunding project products and pricing options to match different buyer preferences. In addition, a creator needs to consider the anticipated project success rate. In the menu design for a crowdfunding project, how would the creator's consideration of project success affect the optimal product line and pricing decisions?

To investigate this question, we propose and analyze a two-period model where a creator may offer a line of products or charge different prices over time to sequentially arriving buyers. The decisions of the earlier buyers are posted to the later arrivals. The buyers decide whether to purchase and which product option to choose according to their valuations. Because the project will not succeed unless the total purchases from all buyers meet the goal, buyers are linked together by the common goal of project success. As a result, given two product options of similar or even *identical* quality, but at different prices, the buyer with a high product valuation may choose the high-price option to ensure the success of the crowdfunding project. This will be the case as long as a buyer perceives that other buyers may have low product valuations. Interestingly, this “overpay” behavior can also improve buyer total surplus. Hence, the introduction of discriminatory pricing strategies, such as a menu, can be win-win for the creator and the buyers. This result is in stark contrast to the traditional situation wherein the lower price option would

be generally preferred, given little or *no* difference in quality. Moreover, the buyers' incentive to collaborate for the project's success also affects the optimal product line design when quality decisions are endogenous. Compared to the traditional situation, a creator using a crowdfunding mechanism is more likely to offer a menu of product options, and the difference in quality between product options tends to be smaller.

We extend the main model in several directions. First, we consider buyers' altruistic motivations such as warm glow, i.e., deriving positive utility from spending more money to support a project. We show that when buyers are altruistic, the main insights for offering a menu of options remain. Moreover, buyers are willing to contribute more to the projects than in the selfish setting. Second, we extend the base model to situations wherein cohorts of buyers arriving in two periods can have different product valuations or there can be different numbers of buyers. Our main findings about menus of options hold in both cases. Surprisingly, a creator's profit can be lower when the chance of having a high-type buyer in the second period is greater. That is because the first high-type buyer, being more optimistic about the second buyer's valuation, is more likely to consider free-riding. Third, we consider demand uncertainty in the number of buyers in each period. Given the possibility of no-shows in one period, we find the results on the optimal menu prices to be the same. In addition, when two cohorts have an uncertain number of buyers, we find that the pledged amount can exceed the target,

resulting in the commonly observed overfunding phenomenon. Finally, we extend the model by allowing the buyers to choose their decision time. When the first buyer can choose to wait and decide later, we find that the first buyer would prefer not to wait, and our main results on the menu strategy hold. When the creator offers the optimal menu strategy in the base model and both buyers decide which period to enter, the creator's profit can be even higher.

### Literature Review

This paper contributes to the extensive marketing literature of product line design. Moorthy (1984) provides a general framework for a monopoly seller's product line design problem. The marketing literature has investigated how product line design decisions may depend on market conditions such as the extent of horizontal differentiation (Desai 2001), the presence of private information (Balachander and Srinivasan 1994) and network externality (Jing 2007), the structure of the distribution channel (Villas-Boas 1998), and customization (Syam et al. 2005, Valenzuela et al. 2009). Consistent with this body of literature, our paper provides new insights into product line design in an emerging business model.

Second, this paper contributes to the public economics literature. Research in public economics has extensively examined *provision point mechanisms* for improving the private provision of public goods (see, e.g., Bagnoli and Lipman 1989, Varian 1994). In the provision point mechanism and crowdfunding, goods will be provided only when the preset contribution level is reached. Otherwise, the parties are not bound to carry through and any monetary contributions are refunded. However, unlike the provision of public goods, a buyer in crowdfunding cannot benefit from a successfully funded project without pledging at a suggested price. Moreover, price decisions and the threshold (i.e., the provision point) are typically treated as exogenous in the public economics literature.

The recent emergence of online crowdfunding has also attracted the attention of academic researchers (Agrawal et al. 2014). Several papers have empirically investigated the herding behavior caused by asymmetric quality information and observational learning from early contributions (see, e.g., Agrawal et al. 2011, Freedman and Jin 2011, Zhang and Liu 2012, Mollick 2014). We isolate the effect of asymmetric information and study specific marketing decisions under the provision point mechanism, as compared to the conventional selling mechanism. Our paper yields new insights into how the crowdfunding business model may affect decisions about optimal product line and pricing.

A mechanism similar to crowdfunding is group buying wherein a seller offers promotional discounts

to a sufficiently large number of committed purchasers. Companies such as Groupon and LivingSocial have used this mechanism. Existing theoretical research has examined many aspects of the group buying mechanism, including the ability to respond to market size uncertainty (Anand and Aron 2003), the use of informed consumers to enhance the valuation of uninformed consumers in their social networks (Jing and Xie 2011), disclosure of the cumulative sign-up information to increase deal success rates (Hu et al. 2013), and to signal a merchant's high quality (Subramanian and Rao 2014). Empirical research has studied consumers' sign-up behavior in group buying with multiple levels of thresholds (Kauffman and Wang 2001) and revealed two types of threshold-induced effects (Wu et al. 2014). While group buying deals are often offered by established businesses, crowdfunding projects studied in this paper are typically associated with new ventures. However, because both mechanisms involve product sales, the insights developed in this paper can be applied to group buying for exclusively designed products and services.

Finally, our model is related to the pay-what-you-want (PWYW) selling scheme wherein buyers can choose to pay any price they wish. Like product design in crowdfunding, PWYW can be an effective price discrimination mechanism (Chen et al. 2012). An important factor for the success of PWYW is the buyer's altruism and fairness concerns (Kim et al. 2009, Chen et al. 2012, Gneezy et al. 2010). We also take into account similar behavioral considerations, such as the altruism and warm glow effect, and examine their influence on the crowdfunding design.

## 2. The Base Model and Analysis

In this section, we develop a two-period model to study the creator's decisions and the buyers' sign-up behavior. Online crowdfunding firms such as Kickstarter allow creators to set a target for each project; a project is deemed to be realized only when the total *amount* pledged exceeds the target. We start with a base model, which assumes an exogenously determined quality, to develop novel insights into the crowdfunding buyer's behavior. We analyze the creator's product line decisions in §2.1.

### 2.1. Model Setup

Consider a simple two-period game wherein a risk-neutral creator adopts a sequential crowdfunding mechanism for selling products. The creator posts a proposed project, with specific product quality and price information, on a crowdfunding platform. The sign-up process expires after two periods. In each period  $t$ , one buyer arrives at the proposed project. We denote the buyer at time  $t$  as  $B_t$ , with  $t = 1, 2$ . For the proposed project to succeed, both buyers must

sign up. This is necessary to model the coordination between buyers. In practice, all crowdfunding projects require many buyers. There are many reasons that a project needs a certain number of buyers and a certain amount of funding to start. For instance, on the supply side, there may be *economies of scale* due to high initial set-up costs. Most digital products fall into this category. On the demand side, the product may exhibit *positive externality*. For the product to be of sufficient value, there must be enough users.

Buyers may have different product valuations. To model this heterogeneity, we assume their valuations are i.i.d. with the following two-point distribution:

$$V_t = \begin{cases} H & \text{with probability } \alpha, \\ L & \text{with probability } 1 - \alpha, \end{cases}$$

where  $H > L > 0$ . On arrival at the project in period 1, buyer  $B_1$  realizes private product valuation, makes the purchase decision, and leaves the site. The creator observes and then announces the purchase decision of  $B_1$ . Then buyer  $B_2$  arrives at the project, realizes a private product valuation, observes the purchase decision of buyer  $B_1$ , and makes her own purchase decision. Both buyers are rational; each makes a purchase decision to maximize her own expected utility.

As mentioned, at the beginning of the game, the creator makes product and pricing decisions, and posts them on a crowdfunding website. In addition, the creator decides the funding target, denoted by  $T$ . The creator commits to a provision point mechanism such that the project succeeds only if the total amount pledged reaches or exceeds  $T$ . Otherwise, the project fails. When making decisions, the creator knows the distribution of product valuations of two buyers, but does not know the exact realized valuations. The creator's goal is to maximize the expected profit from the proposed project.<sup>3</sup> We assume, without loss of generality, that there is no transaction cost associated with pledging or rewarding, and that there is no time discounting over the sign-up horizon.

Next we define alternative pricing strategies with the target endogenized to be consistent with the strategy. We then analyze the profitability of the strategy.

## 2.2. Alternative Pricing Policies

**Uniform Pricing.** With a uniform pricing strategy, the creator posts a single price  $p$  for her product. Because the project succeeds only if both buyers sign up and pay  $p$ , the creator can effectively set  $T = 2p$ .

<sup>3</sup> In reality, creators can have different goals. An entrepreneur is likely to concentrate on expected revenue and profit, but an artist may also want to reach a wide audience. We have chosen the profit-maximization framework so that our results will be directly comparable to existing work on product-line design.

Although price  $p$  can take any positive value, given the two-point distribution of product valuations, the optimal price should be  $p = H$  or  $p = L$ . Thus, it suffices to consider the following two cases.

**Margin Strategy (H).** With this strategy, the creator sets the price at  $p^H = H$  and the target at  $T^H = 2H$ . Any target beyond  $2H$  would consign the project to failure. Any target in  $(H + L, 2H]$  is equivalent to  $2H$ , which sells only to high-type buyers, consistent with the term margin strategy. Under this strategy, a high-type buyer will sign up, but a low-type buyer will decline. This strategy has a success rate of  $s^H = \alpha^2$  and the creator has an expected profit of  $\pi^H = 2\alpha^2 H$ .

**Volume Strategy (L).** With this strategy, the creator sets the price at  $p^L = L$  and the target at  $T^L = 2L$ . Any target below  $2L$  is equivalent to  $2L$ , with only the low price being paid, consistent with the term volume strategy. Under this strategy, both buyers sign up, regardless of their types, and the project always succeeds, i.e.,  $s^L = 1$ . The creator's profit is  $\pi^L = 2L$ .

Compared with the margin strategy, the volume strategy gives the creator a higher chance of project success; however, given that the project always succeeds, the volume strategy yields a lower profit margin.

**Intertemporal Pricing (D).** With this strategy, a creator sets different prices for different periods, denoted by  $p_t^D$  for period  $t$ ,  $t = 1, 2$ . Following the same logic as before, given the two-point distribution of product valuations, the optimal price in each period must be  $L$  or  $H$ . That leads to two candidate strategies,  $(p_1^D, p_2^D) = (H, L)$  or  $(p_1^D, p_2^D) = (L, H)$ . The creator's goal is  $T^D = H + L$ . Any target in  $(2L, H + L]$  is equivalent to  $H + L$ , which leads to different prices charged in different periods, consistent with the term intertemporal pricing strategy. The success rate is  $s^D = \alpha$  and the creator's expected profit is  $\pi^D = \alpha(H + L)$ . Note that since the buyers arriving at different periods have the same distribution of product valuations, the creator is indifferent between these two intertemporal pricing strategies. However, as shown later in §4.2, the creator may prefer one type over another when buyers have different product valuations.

**Menu Pricing (M).** With this strategy, the creator posts a menu containing a high price  $p_h^M$  and a low price  $p_l^M$ , where  $p_l^M \leq L \leq p_h^M \leq H$ . Unlike intertemporal pricing, the optimal prices in the menu may not be equal to the two valuation points  $H$  and  $L$  (see Lemma 1 below). The creator sets the target at the sum of the high and low prices, i.e.,  $T^M = p_h^M + p_l^M$ . Any target in  $(2p_l^M, p_h^M + p_l^M]$  is equivalent to  $p_h^M + p_l^M$ , which requires at least one buyer to pay the high price.

The menu pricing strategy proposed here may not appear to be valid because the same quality product

has different prices. This is done intentionally to tease out a buyer's incentive to overpay in crowdfunding.<sup>4</sup> With the traditional selling mechanism, such a menu could not work because each buyer would always choose the lower price option. However, in crowdfunding, a buyer (who is also a funder) may choose the higher price if such a choice could substantially increase the likelihood of project success. In other words, one buyer's behavior affects another buyer's expected utility. Positive externality arises through the common goal of project success.

To solve the optimal menu strategy, we use the backward induction method. In period 2, buyer  $B_2$  observes the contribution of the earlier buyer  $B_1$  and makes her own decision accordingly. Specifically, if  $B_1$  has signed up at  $p_h^M$ ,  $B_2$  always signs up at the low price  $p_l^M \leq L$ , regardless of her product valuations. On the other hand, if  $B_1$  has signed up at  $p_l^M$ ,  $B_2$  either pledges  $p_h^M$  or does not sign up at all: It is meaningless for  $B_2$  to sign up at  $p_l^M$  because the project will fail. Hence, buyer  $B_2$  should sign up at  $p_h^M$  if her product valuation is  $H$ . Otherwise, she should not sign up. Recall that the probability is  $\alpha$  for a buyer's product valuation to be  $H$ .

Next we return to the first period and consider buyer  $B_1$ . If her product valuation is  $L$ , she always signs up at  $p_l^M$ . Otherwise, she can choose from two options. By choosing the low-price option  $p_l^M$ ,  $B_1$  expects a larger surplus  $H - p_l^M$  but a lower success rate at  $\alpha$ . Alternatively, by choosing the high-price option  $p_h^M$ , the buyer expects a smaller surplus  $H - p_h^M$  but a higher success rate at 1. A high-type  $B_1$  would prefer the high-price option  $p_h^M$  over the low-price option  $p_l^M$  if and only if the following incentive-compatibility (IC) condition is satisfied:

$$\alpha(H - p_l^M) \leq H - p_h^M. \quad (\text{IC})$$

The creator decides the optimal menu of prices to maximize the expected profit, subject to the condition (IC). Analyzing the creator's problem leads to the following lemma.

**LEMMA 1 (OPTIMAL MENU STRATEGY).** *With this menu strategy, the creator's optimal prices are  $p_h^M = (1 - \alpha)H + \alpha L$ ,  $p_l^M = L$ , and the optimal target is  $T^M = (1 - \alpha)H + (1 + \alpha)L$ . The corresponding success rate is  $s^M = \alpha(2 - \alpha)$ , and the expected profit is  $\pi^M = \alpha(2 - \alpha) \cdot ((1 - \alpha)H + (1 + \alpha)L)$ .*

Lemma 1 indicates that with the menu pricing strategy (given that all others are the same), as long as the high price  $p_h^M$  is low enough to satisfy the IC condition, the high-type buyer  $B_1$  prefers to pay

the high price, even though a lower price option is available. The amount of overpayment is  $p_h^M - p_l^M = (1 - \alpha)(H - L)$ , which increases with product valuation gap  $H - L$  and decreases with  $\alpha$ . Thus, when product valuation is more heterogeneous between different types of buyers or when buyer  $B_1$  is more pessimistic about the product valuation of buyer  $B_2$ , a high-type buyer  $B_1$  has a greater incentive to overpay. With a larger gap  $H - L$ , a high-type buyer  $B_1$  derives more utility from the project and is thus more willing to make a sacrifice to ensure the project's success. Similarly, with a smaller  $\alpha$ , the risk of project failure is high, and thus the incentive to overpay is higher. As  $\alpha$  decreases from 1 to a small value  $\epsilon > 0$ , the amount of overpayment increases from 0 to  $(1 - \epsilon)(H - L)$ , close to  $H - L$ .

When a high-type  $B_1$  chooses price option  $p_h^M$ , she enjoys a surplus of  $\alpha(H - L)$ . Because the project will succeed, buyer  $B_2$  will choose the low price  $p_l^M = L$ . Otherwise, had buyer  $B_1$  chosen  $p_l^M$ , a high-type buyer  $B_2$  would have to pay  $p_h^M$  and incur a reduction of surplus  $(1 - \alpha)(H - L)$ . Thus, when the high-type buyer  $B_1$  pays the higher price, the overpayment has a *positive externality* effect on the second buyer's surplus. Moreover, the size of the positive externality effect increases with the high price option in the menu. Thus, the crowdfunding mechanism not only artificially creates an externality effect among buyers' decisions but also endogenously determines the size of that externality effect.

### 2.3. Optimal Pricing Strategy

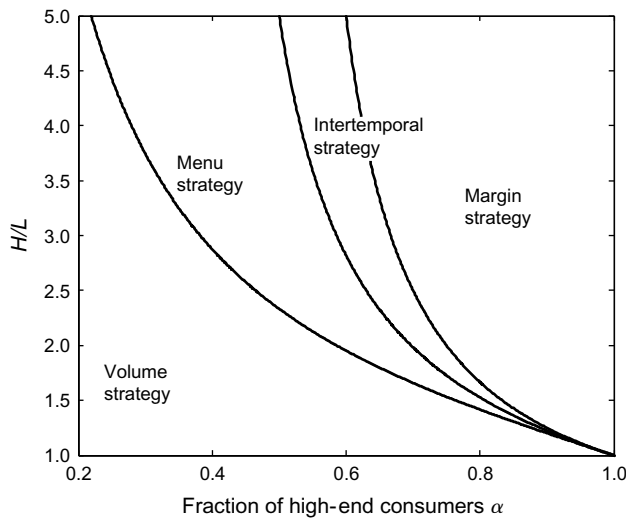
The creator determines the optimal pricing strategy by comparing the expected profits from each of the alternative pricing strategies. We summarize our analysis in the proposition below.

**PROPOSITION 1 (OPTIMAL PRICING STRATEGY).** *The creator's optimal strategy is*

- (i) *volume strategy, if  $H/L \leq (2 - \alpha^2)/(\alpha(2 - \alpha))$ ;*
- (ii) *menu strategy, if  $(2 - \alpha^2)/(\alpha(2 - \alpha)) \leq H/L$  and  $\alpha \leq (3 - \sqrt{5})/2$ , or  $(2 - \alpha^2)/(\alpha(2 - \alpha)) \leq H/L \leq (1 + \alpha - \alpha^2)/(3\alpha - \alpha^2 - 1)$ ;*
- (iii) *intertemporal strategy, if  $\frac{1}{2} \leq \alpha$  and  $(1 + \alpha - \alpha^2)/(3\alpha - \alpha^2 - 1) \leq H/L \leq 1/(2\alpha - 1)$ , or  $(3 - \sqrt{5})/2 \leq \alpha \leq \frac{1}{2}$  and  $(1 + \alpha - \alpha^2)/(3\alpha - \alpha^2 - 1) \leq H/L$ ;*
- (iv) *margin strategy, if  $\frac{1}{2} \leq \alpha$  and  $1/(2\alpha - 1) \leq H/L$ .*

Proposition 1 indicates that each of the four pricing strategies can be optimal within certain parameter subspaces. We illustrate the results in Figure 2. The vertical axis represents the ratio of high-type to low-type buyer's product valuations  $H/L$ ; the horizontal axis represents the fraction of high-type buyers ( $\alpha$ ) in the market. The figure shows that uniform pricing strategies are optimal in two extreme cases. Specifically, given the valuation  $L$ , the volume strategy is

<sup>4</sup> The price menu can be close to actual practice. Many projects on Kickstarter contain levels with *minute* quality differences.

**Figure 2** Optimal Strategy with Different Values of  $H/L$  and  $\alpha$ 

optimal when buyers are unlikely to have high product valuation (i.e., small  $\alpha$ ) or when high- and low-type buyers have a narrow valuation gap (i.e.,  $H/L$  is close to 1). Intuitively, if both buyers are very likely to have a low product valuation, the creator should pursue the volume strategy. The expected gain from targeting high-type buyers only is not worth the risk of project failure. At the other extreme, if buyers are very likely to have a high valuation (i.e., large  $\alpha$ ) and the valuation gap between high- and low-type buyers is large (i.e., large  $H/L$ ), the creator should choose the margin strategy. In other words, if both buyers are very likely to have a product valuation that is much higher than the low valuation, the creator should pursue the margin strategy. The gain from targeting high-type buyers is large, and the risk is bearable.

Two types of discriminatory pricing strategies, the intertemporal and the menu, can be more profitable than uniform pricing strategies when the fraction of high-type buyers ( $\alpha$ ) is not very large and the valuation ratio ( $H/L$ ) is large enough, in other words, when buyers believe that others may have low product valuations that are sufficiently heterogeneous. (The difference between these two discriminatory pricing strategies is timing. While the same menu of two options exists in both periods with a menu pricing strategy, a unique option is available in each period with an intertemporal pricing strategy.) First, with our model, note that an optimal discriminatory pricing strategy degenerates into a uniform pricing strategy in the traditional selling setting. The intertemporal or menu pricing strategy becomes optimal with a crowdfunding mechanism because two buyers are linked by a common target. As a result, a high-type buyer may choose the high-price option to compensate for the small contribution from a low-type buyer. Second, the buyers can achieve coordination without any explicit

**Table 1** Success Rate and Target

|                        | Success rate         | Target                          |
|------------------------|----------------------|---------------------------------|
| Volume strategy        | 1                    | $2L$                            |
| Menu strategy          | $2\alpha - \alpha^2$ | $(1 - \alpha)H + (1 + \alpha)L$ |
| Intertemporal strategy | $\alpha$             | $H + L$                         |
| Margin strategy        | $\alpha^2$           | $2H$                            |

interactions. In our model, self-interested buyers do not incorporate other buyers' utilities into their objectives (as in Chen and Li 2013), nor do some buyers communicate with others to increase their valuations (as in Jing and Xie 2011).

Table 1 shows the target amount and project success rate for each type of pricing strategy. The target amount increases in the following order: volume strategy, menu strategy, intertemporal strategy, and margin strategy; the project success rate decreases in the same order. When the fraction of high-type buyers ( $\alpha$ ) increases, the differences in the success rate among different strategies diminish, but the differences in the target levels remain large. A high target leads to a low project success rate, and vice versa.<sup>5</sup>

The corollary that follows summarizes the social welfare implications of discriminatory pricing strategies.

**COROLLARY 1 (SOCIAL WELFARE).** *The introduction of discriminatory strategies can improve creator and buyer surplus.*

(i) *If  $(2 - \alpha)/\alpha < H/L < \max\{(3 - \sqrt{5})/2, (1 + \alpha - \alpha^2)/(3\alpha - \alpha^2 - 1)\}$ , the introduction of menu strategy improves both creator and buyer surplus over the optimal strategy of the other three strategies.*

(ii) *If  $\frac{1}{2} \leq \alpha$  and  $(2 - \alpha)(1 + \alpha)/(5\alpha - 2 - \alpha^2) \leq H/L \leq 1/(2\alpha - 1)$ , the introduction of intertemporal strategy improves both creator and buyer surplus over the optimal strategy of the other three strategies.*

Corollary 1 states that discriminatory pricing strategies can improve buyer surplus and social welfare. With discriminatory pricing strategies, the creator can serve more buyers. Margin strategy serves high-type buyers only. As to volume strategy, because of low profitability it is often not sustained as the optimal pricing strategy, even though it serves all buyers. In contrast, with the menu and intertemporal strategies, the creator can reach all high-type buyers and a fraction of low-type buyers and, at the same time, achieve high profitability.

<sup>5</sup> Our model can be easily adapted to situations wherein a not-for-profit creator wants to maximize the success rate, subject to raising enough funds to cover set-up costs in advance. The amount of fixed set-up costs can become the exogenous target. Table 1 can be used as a guide for the optimal pricing strategy given the exogenous target. For example, if the exogenous target  $T$  falls in the range  $[2L, (1 - \alpha)H + (1 + \alpha)L]$ , the menu strategy maximizes the success rate.



*Discussions.* In a model without product quality differentiation, the menu pricing strategy can be optimal in a crowdfunding mechanism. When buyers are sufficiently heterogeneous in product valuation, offering a menu of prices can help achieve a better balance between volume (or success rate) and margin. Note that a self-interested high-type buyer might be willing to pay extra to ensure the project's success. Thus, by turning buyers into funders, the crowdfunding mechanism enhances coordination among different buyers. Moreover, the menu pricing strategy, by choosing a proper level of high-price options below  $H$ , moderates the high-type buyer's sacrifice and optimizes the coordination incentive. Crowdfunding creates compatibility between the purchases of two buyers who share the common goal of the project success. As a result, each buyer's behavior has an external effect on other buyers' utilities. The extent of that externality effect is regulated by the price difference in the menu.

The high-type buyer's incentive to pay extra relies on the belief that the creator is committed to the provision point mechanism, i.e., the project will not be carried out unless the target is met. Although it is not the focus of this paper, we have conducted a formal analysis to confirm that when a menu strategy is optimal, it is in the best interest of the creator to commit to the provision point mechanism. Intuitively, the absence of such a commitment would jeopardize the ability of the menu strategy to price discriminate among buyers. If a high-type buyer expects the creator to continue with the project even if the target is not met, there would be little incentive for the buyer to pay extra. (Please see the online appendix (available as supplemental material at <http://dx.doi.org/10.1287/mksc.2014.0900>) for a detailed analysis.)

### 3. Product Line Design

In this section, we extend the base model to allow the creator to offer two vertically differentiated products. We explore how the crowdfunding mechanism may alter the optimal product line design, specifically, the optimal quality gap between product options. For this analysis, we modify the base model as follows: First, buyers' valuations depend on the quality of the products. Specifically, for a quality level  $Q$ , we assume product valuation  $V_h = QH$  for a high-type buyer, and valuation  $V_l = QL$  for a low-type buyer. The base model is a special case, with the quality level fixed at  $Q = 1$ . Second, in keeping with the existing literature, we assume that the production cost is a function of quality. In particular, we assume that the unit production cost of a good with a quality level  $Q$  is  $Q^2/2$ . This quadratic form is widely used in the marketing literature (see, e.g., Guo and Zhang 2012). Finally, to account for the development cost, we assume that the

creator must produce two units of products, which may be available in different qualities.

We denote the creator's menu decision by  $(Q_l^M, P_l^M)$  and  $(Q_h^M, P_h^M)$ . (To distinguish the product line model from the base model, we use capital letters.) The creator's funding target is  $T^M = P_h^M + P_l^M$ . Analysis of this model is similar to that of the base model. The major distinction is the IC condition that ensures self-selection by a high-type buyer  $B_1$ . It now becomes

$$\alpha(HQ_l^M - P_l^M) \leq HQ_h^M - P_h^M, \quad (1)$$

where the buyer's surplus hinges on quality, too. The creator's expected profit is given by

$$\Pi^M = (\alpha^2 + 2\alpha(1 - \alpha)) \left( P_h^M + P_l^M - \frac{(Q_h^M)^2}{2} - \frac{(Q_l^M)^2}{2} \right), \quad (2)$$

subject to the IC condition (1) and  $P_l^M \leq LQ_l^M$ . For given quality levels  $(Q_h^M, Q_l^M)$ , clearly the optimal prices are achieved when both inequalities in the constraints are binding, i.e.,  $P_h^M = HQ_h^M - \alpha(H - L)Q_l^M$ ,  $P_l^M = LQ_l^M$ . The first order condition of the creator's problem yields the optimal quality choices  $Q_h^M = H$ ,  $Q_l^M = L - \alpha(H - L)$ . We summarize the optimal (interior or boundary) solution as follows:

**PROPOSITION 2 (OPTIMAL PRODUCT LINE DESIGN).**  
In the product line model,

(i) if  $H/L \leq (1 + \alpha)/\alpha$ , the optimal quality levels are  $(Q_h^M, Q_l^M) = (H, \Delta)$ , where  $\Delta \equiv L - \alpha(H - L) \leq L$ , and the optimal prices are  $(P_h^M, P_l^M) = (H^2 - \alpha(H - L)\Delta, L\Delta)$ . The corresponding expected profit of the creator is  $\Pi^M = (\alpha(2 - \alpha)/2) \cdot ((1 + \alpha^2)H^2 - 2\alpha(1 + \alpha)HL + (1 + \alpha)^2L^2)$ ;

(ii) if  $H/L \geq (1 + \alpha)/\alpha$ , the optimal quality levels are  $(Q_h^M, Q_l^M) = (H, 0)$ , and the optimal prices are  $(P_h^M, P_l^M) = (H^2, 0)$ . The corresponding expected profit of the creator is  $\Pi^M = (\alpha(2 - \alpha)/2)H^2$ .

To see the effect of the crowdfunding mechanism on product line design, we compare the results of this model with the traditional selling situation. In that situation, the current model would have a different self-selection IC condition

$$HQ_l^T - P_l^T \leq HQ_h^T - P_h^T, \quad (3)$$

where the superscript  $T$  specifies the traditional model. Here the creator's goal is to maximize her expected profit

$$\Pi^T = \alpha \left( P_h^T - \frac{(Q_h^T)^2}{2} \right) + (1 - \alpha) \left( P_l^T - \frac{(Q_l^T)^2}{2} \right), \quad (4)$$

subject to the IC condition (3) and  $P_l^T \leq LQ_l^T$ . Similarly, the optimal prices are achieved when both inequalities in the constraints are binding, i.e.,  $P_h^T = HQ_h^T - (H - L)Q_l^T$ ,  $P_l^T = LQ_l^T$ . For purpose of comparison, we summarize the optimal solution to the traditional problem as follows:



LEMMA 2. In the traditional product line design problem, the optimal strategy is:

- (i) if  $H/L \leq 1/\alpha$ ,  $Q_h^T = H$ ,  $Q_l^T = (L - \alpha H)/(1 - \alpha)$  and  $P_h^T = (H^2 - (1 + \alpha)HL + L^2)/(1 - \alpha)$ ,  $P_l^T = ((L - \alpha H)L)/(1 - \alpha)$ ;
- (ii) if  $H/L \geq 1/\alpha$ ,  $Q_h^T = H$ ,  $Q_l^T = 0$  and  $P_h^T = H^2$ ,  $P_l^T = 0$ .

Comparing the quality differences between  $(Q_h^T - Q_l^T)$  and  $(Q_h^M - Q_l^M)$ , we have:

PROPOSITION 3 (LESS DIFFERENTIATION IN CROWDFUNDING). Qualities are less differentiated in the crowdfunding scenario.<sup>6</sup>

To understand Proposition 3, note first that in the case of perfect discrimination, the creator knows each buyer's true type and can supply products of quality  $H$  to high-type buyers and products of quality  $L$  to low-type buyers. When buyers hold private information on quality valuations, to satisfy the self-selection condition the creator must distort quality levels downward. According to our analysis, in both traditional and crowdfunding settings,  $Q_h^T = Q_h^M = H$ . This is the familiar "no distortion at-the-top" result (Moorthy 1984). The downward quality distortion comes from the low-quality product, and is smaller in the crowdfunding setting, i.e.,  $Q_l^T < Q_l^M < L$ .

We explain this result through IC conditions (1) and (3), together with objective functions (2) and (4). The low-quality option is associated with project success rate  $\alpha$  in crowdfunding's IC condition (1); the associated success rate is 1 in the IC condition (3) of the traditional setting. The difference in the success rates is also reflected in the objective functions. Intuitively, we can see that in crowdfunding, high-type buyers are concerned about both the success rate of the project and surplus from purchase. If a high-type buyer had deviated from the high-quality option and chosen the low-quality product, the buyer would experience a higher surplus from the option, but face a lower success rate. In light of this trade-off, which itself deters deviation and does not exist in the traditional setting, the creator can afford a less downward distortion, i.e., to set the low-option quality higher.

### 3.1. Strategy Comparison

Next we evaluate the profitability of the menu strategy compared to the three other strategies: margin ( $H$ ), volume ( $L$ ), and intertemporal ( $D$ ). For each strategy, we analyze the optimal quality level or levels, and its corresponding expected profit. We summarize the results in the next lemma.

LEMMA 3. When product qualities are endogenized, the creator's optimal decisions under each of the three strategies are as follows:

- (i) margin strategy:  $Q^H = H$ ,  $P^H = H^2$ , and  $\Pi^H = \alpha^2 H^2$ ;
- (ii) volume strategy:  $Q^L = L$ ,  $P^L = L^2$ , and  $\Pi^L = L^2$ ;
- (iii) intertemporal strategy:  $Q_t^D = H$ ,  $P_t^D = H^2$ ,  $Q_{3-t}^D = L$ ,  $P_{3-t}^D = L^2$ , where the solutions are symmetric for  $t = 1, 2$ . Moreover,  $\Pi^D = (\alpha/2)(H^2 + L^2)$ .

In the intertemporal strategy, we can also measure the optimal quality gap between the two products, only one of which is offered in a period. Clearly, the optimal quality gap with the intertemporal strategy,  $H - L$ , is also smaller than that in the traditional product design. The driving force is similar to that which we explained for the menu strategy. We compare the profitability of various pricing strategies, leading to the following proposition:

PROPOSITION 4. When product qualities are endogenized, the creator's optimal strategy is

- (i) volume strategy, if  $H/L \leq \tau_1$ , where  $\tau_1 = (-2\alpha^2 - \alpha^3 + \alpha^4 - \sqrt{4\alpha - 6\alpha^2 + \alpha^4 + 2\alpha^5 - \alpha^6})/(-2\alpha + \alpha^2 - 2\alpha^3 + \alpha^4)$ ;
- (ii) menu strategy, if  $\tau_1 \leq H/L \leq \tau_2$ , or  $\tau_1 \leq H/L$  and  $\alpha \leq \frac{2}{3}$ , where  $\tau_2 = \min((1 + \alpha)/\alpha, (-2\alpha - \alpha^2 + \alpha^3 - \sqrt{-4 + 9\alpha^2 + 2\alpha^3 - 3\alpha^4})/(-2 + 3\alpha - 2\alpha^2 + \alpha^3))$ ;
- (iii) volume strategy, if  $\tau_2 \leq H/L$  and  $\frac{2}{3} \leq \alpha$ .

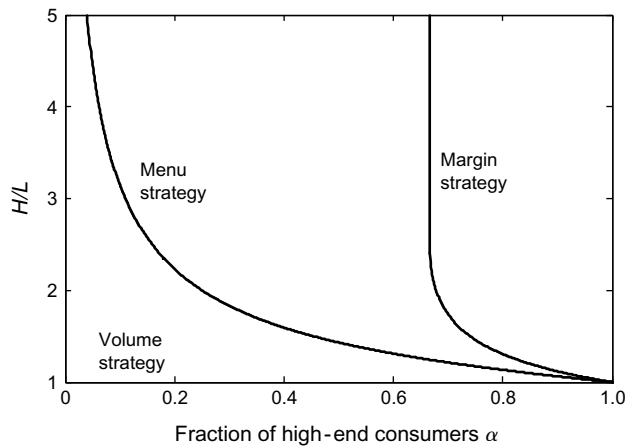
Proposition 4 confirms that the same insight obtained from Proposition 1 for the base model applies to the generalization under which product qualities are endogenized. That is, in crowdfunding the menu pricing strategy, as a discriminatory choice, can be more profitable than uniform pricing strategies. Unlike the base model, when product qualities are endogenized the intertemporal strategy can be shown to be dominated by other strategies, though it may still be more profitable than uniform pricing strategies under certain conditions.<sup>7</sup> As in Figure 2 in the base model, Figure 3 demonstrates the optimal product and pricing strategy under different market conditions. From Figure 3, we see again that the menu strategy becomes optimal when the fraction of high-type buyers ( $\alpha$ ) is not too large and the valuation differentiation between two types of buyers ( $H/L$ ) is large enough. Again, this figure implies that no single marketing strategy dominates in all parameter spaces. Creators should tailor their product and pricing strategies to the specific market conditions associated with their projects.

Our main insights about the high-type buyer's behavior and implications for menu design have

<sup>6</sup> Unless otherwise specified, any comparison or monotonicity is in its weaker sense. For example, less means no more and increasing means non-decreasing.

<sup>7</sup> The intertemporal strategy is more profitable than the volume strategy when  $H/L \geq \sqrt{(2 - \alpha)/\alpha}$ , and more profitable than the margin strategy when  $H/L \leq 1/\sqrt{2\alpha - 1}$  or  $\alpha \geq \frac{1}{2}$ .

**Figure 3** Optimal Strategy with Different Values of  $H/L$  and  $\alpha$  in Product Line Design



strong relevance to crowdfunding practices. Although high-type buyers may not be the majority, their contributions are critical to project success. To collect some empirical evidence, we monitored the progress of all new projects launched on Kickstarter from 15:15 to 23:15 on January 15, 2014. There were a total of 60 such projects; 58% succeeded; 95% posted a menu consisting of multiple levels of reward-price offers. On average, the top 10% of buyers contributed 52.2% of the total pledged amount. There were a total of 8,754 buyers, 87.6% of whom paid the exact prices suggested. Thus, consistent with our results, a majority of consumers paid according to the menus.

## 4. Model Extensions

In this section we discuss a number of extensions to the base model. Analyzing these extensions not only establishes the robustness of our results on crowdfunding product and pricing decisions but also deepens our understanding of these issues. To simplify the discussion, we may concentrate on the menu strategy when similar insights are applicable to the intertemporal strategy.

### 4.1. Noneconomic Motivations

The main model assumes that all buyers are self-interested and make decisions to maximize their own surplus. However, for many crowdfunding projects, especially those posted by artists and not-for-profit organizations, the buyers can be influenced by noneconomic or altruistic motives (Mollick 2014). Here we consider two commonly examined forms of such motives, i.e., warm glow and the prestige effect. We also examine the implications for product and pricing decisions. In both cases we add a term for noneconomic motivation to a buyer's utility function.

In the warm-glow model, a buyer's utility function becomes  $U = (V - p) + \lambda \cdot p$ , where  $(V - p)$  is the

economic surplus in the base model and  $p$  represents the amount the buyer contributes to the project. The parameter  $\lambda \in [0, 1)$  represents the significance of the warm-glow effect. This formulation follows the previous literature on warm glow and altruistic motivation (see, e.g., Andreoni 1990).

We now examine the influence of the warm-glow effect on the menu strategy. Suppose the creator sets the prices at  $p_h^{M_w}$  and  $p_l^{M_w}$ . To motivate a low-type buyer to participate, we need to make sure that  $L - p_l^{M_w} + \lambda p_l^{M_w} \geq 0$ . To ensure that a high-type buyer selects the high-price option, we need to ensure the following IC condition:  $H - p_h^{M_w} + \lambda p_h^{M_w} \geq \alpha(H - p_l^{M_w} + \lambda p_l^{M_w})$ . Incorporating these two constraints into the creator's problem, we can solve for the optimal pricing strategy, summarized as follows:

**PROPOSITION 5 (WARM GLOW).** *When buyers experience the warm-glow effect, the optimal menu strategy is  $(p_h^{M_w}, p_l^{M_w}) = (((1 - \alpha)H + \alpha L)/(1 - \lambda), L/(1 - \lambda))$ , which amplifies the optimal menu prices in the base model by a factor of  $1/(1 - \lambda)$ .*

The prestige effect is a discrete form of the warm-glow effect based on relative contributions. When a creator offers several categories of contributions, those who choose the higher categories could experience the prestige values (Harbaugh 1998). Assume that a buyer's additional utility from the prestige effect is  $u_p$ . To motivate a high-type buyer to choose the high-price option, it is necessary to ensure that  $H - p_h^{M_w} + u_p \geq \alpha(H - p_l^{M_w})$ . Given this revised IC condition, the buyer's optimal pricing strategy is summarized as follows.<sup>8</sup>

**PROPOSITION 6 (PRESTIGE).** *When buyers experience the prestige effect, the optimal menu strategy is  $(p_h^{M_w}, p_l^{M_w}) = ((1 - \alpha)H + \alpha L + u_p, L)$ .*

The above propositions imply that, with either the warm-glow or prestige effect, the parameter spaces under which a creator should adopt the menu strategy expand. Moreover, both the high-price option and the price gap increase. Intuitively, we can see that both effects increase the expected value of and the relative preference for the high-price option. Thus, both warm-glow and prestige effects provide additional justifications for the creator to offer more than one option.

The base model considers one buyer in each period with the same distribution of valuation. Next we examine two alternative models. In the first, two buyers have different valuations. In the second, a different number of buyers arrive in two periods.

<sup>8</sup> When prestige effect is proportional to the additional amount paid with coefficient  $\zeta$ , the IC condition becomes  $H - p_h^{M_w} + \zeta(p_h^{M_w} - p_l^{M_w}) \geq \alpha(H - p_l^{M_w})$ . The optimal menu strategy is then  $(p_h^{M_w}, p_l^{M_w}) = ((1 - \alpha)H + (\alpha - \zeta)L)/(1 - \zeta), L)$ .

## 4.2. Time-Varying Valuations

Two buyers arriving in different periods may not follow the same distribution of product valuations. For example, buyers with a special interest in certain types of projects are more likely to search for such projects and arrive at them earlier. A creator may also share the proposed project first with family and friends, who may be willing to pay more to show their support. To consider such time-varying valuations, we assume that the buyers arriving at two periods follow different value distributions. Specifically, let  $\alpha_t$  be the probability that buyer  $B_t$ ,  $t = 1, 2$ , has high valuation  $H$ . Then the creator's expected profit is  $\pi^{H_h} = 2\alpha_1\alpha_2H$  with the margin strategy; the expected profit is  $\pi^{L_h} = 2L$  with the volume strategy. With the intertemporal pricing strategy, the creator charges the high price during the period with the larger  $\alpha$ , and the expected profit is  $\pi^{D_h} = \max(\alpha_1, \alpha_2)(H + L)$ .

**LEMMA 4.** *With time-varying product valuations, the creator's optimal menu strategy is  $p_h^{M_h} = (1 - \alpha_2)H + \alpha_2L$ ,  $p_l^{M_h} = L$ . The corresponding expected profit is  $\pi^{M_h} = (\alpha_1 + \alpha_2 - \alpha_1\alpha_2)((1 - \alpha_2)H + (1 + \alpha_2)L)$ .*

The proof is analogous to that of Lemma 1. A comparison of the expected profits with various pricing strategies leads to the following proposition:

**PROPOSITION 7.** *The menu pricing strategy is more profitable*

- (i) *than the volume strategy if  $(2 - \alpha_1 + \alpha_2 - \alpha_1\alpha_2)/(\alpha_1 + \alpha_2 - \alpha_1\alpha_2) \leq H/L$ ;*
- (ii) *than the margin strategy if  $H/L \leq ((1 + \alpha_2) \cdot (\alpha_1 + \alpha_2 - \alpha_1\alpha_2))/(4\alpha_1\alpha_2 + \alpha_2^2 - \alpha_1 - \alpha_2 - \alpha_1\alpha_2^2)$ , or,  $\alpha_1$  and  $\alpha_2$  satisfy  $\alpha_1 + \alpha_2 - 4\alpha_1\alpha_2 - \alpha_2^2 + \alpha_1\alpha_2^2 \geq 0$ ;*
- (iii) *than the intertemporal strategy if  $H/L \leq -(\alpha + \alpha_2^2 - \alpha_1\alpha_2^2)/(\alpha - 2\alpha_1\alpha_2 - \alpha_2^2 + \alpha_1\alpha_2^2)$ , or,  $\alpha_1$  and  $\alpha_2$  satisfy  $2\alpha_1\alpha_2 + \alpha_2^2 - \alpha_1\alpha_2^2 \leq \alpha$ , where  $\alpha \equiv \min(\alpha_1, \alpha_2)$ .*

Proposition 7 is consistent with the results for the menu pricing strategy in the base model. Interestingly,  $\alpha_1$  and  $\alpha_2$  have very different effects on the creator's profit. Taking derivatives of  $\pi^{M_h}$  with respect to  $\alpha_1$  and  $\alpha_2$ , respectively, yields the following result:

**COROLLARY 2.** *With time-varying product valuations, a creator following the menu strategy sees the expected profit increasing in  $\alpha_1$ ; increasing in  $\alpha_2$  if  $\alpha_2 \leq \alpha_2^* \equiv (H - 2\alpha_1H + L)/(2(1 - \alpha_1)(H - L))$ , and decreasing in  $\alpha_2$  if  $\alpha_2 \geq \alpha_2^*$ .*

Though it is not difficult to see the first part of Corollary 2, i.e., that the creator's expected profit increases in  $\alpha_1$ , the second part is intriguing. The latter implies that the buyer may gain more when buyer  $B_2$ 's expected valuation  $\alpha_2H + (1 - \alpha_2)L$  decreases. To understand this, recall that the creator's expected profit hinges on the success rate and the target, which equals  $p_h^{M_h} + p_l^{M_h}$ . While a larger  $\alpha_2$

increases the success rate, it can reduce the price  $p_h^{M_h}$  and hence the target: When  $\alpha_2$  is large enough, with the expectation that  $B_2$  has a greater chance of being a high type,  $B_1$  may be reluctant to pay the high price, hoping that  $B_2$  pays it instead. In short,  $B_1$  is more likely to free ride when  $\alpha_2$  rises. With these forces, the effect of  $\alpha_2$  on the creator's profit is no longer monotonic.

Even after all of the alternative pricing strategies are considered, the expected profit from the best pricing strategy may still decrease in  $\alpha_2$ . These results have implications for how creators should manage the buyers' arrival sequence and their beliefs about the product valuations of future buyers. Under some conditions, persuasive marketing campaigns to increase a buyer's valuation in period 2 can backfire and reduce the creator's profit. This implies that a creator may benefit from certain demarketing efforts in the second period (see, e.g., Miklos-Thal and Zhang 2013, Gerstner et al. 1993, Pazgal et al. 2013).

## 4.3. A Two-Cohort Model

Instead of assuming one buyer in each period, we now consider a cohort of buyers arriving in each period  $t$ ,  $t = 1, 2$ , but keep the assumption of identical value distributions. We let the size of the two cohorts be  $n_1$  and  $n_2$ , respectively. As in the base model, here the valuation distributions  $V_t$  for both periods are i.i.d., following a two-point distribution, equal to  $V_t = H$  with probability  $\alpha$  and  $V_t = L$  with probability  $(1 - \alpha)$ . We further assume that the project requires all buyers from both cohorts to participate.

The analysis of the margin and volume strategies proceeds in the same way as in the base model, except that the targets are now  $(n_1 + n_2)H$  and  $(n_1 + n_2)L$ , respectively. The expected profits with these two strategies are  $\pi^{H_c} = \alpha^2(n_1 + n_2)H$  and  $\pi^{L_c} = (n_1 + n_2)L$ , respectively. With the optimal intertemporal pricing strategy, the creator charges cohort 1 price  $H$  and cohort 2 price  $L$  if  $n_1 \geq n_2$  (which is reversed if  $n_1 < n_2$ ), and the expected profit is  $\pi^{D_c} = \alpha(n_1H + n_2L)$ .

With the menu pricing strategy, we generalize the argument made in the base model that the project is successful only if one buyer is of the high type. In the extended model, a project succeeds only when one cohort of buyers are of high type. Correspondingly, the target will be  $T^{M_c} = \max(n_1, n_2)p_l^{M_c} + \min(n_1, n_2)p_h^{M_c}$ , where  $p_l^{M_c} \leq L, p_h^{M_c} \leq H$  are the menu prices offered in both periods. Because each buyer can pay between  $p_l^{M_c}$  and  $p_h^{M_c}$ , the total contribution from the first cohort of buyers will be between  $n_1p_l^{M_c}$  and  $n_1p_h^{M_c}$ . Suppose that the first cohort has paid  $\lambda \in$

$[n_1 p_l^{M_c}, n_1 p_h^{M_c}]$ , and the remaining amount needed is  $T^{M_c} - \lambda > 0$ . The conditional success rate is then

$$s^{M_c} = \begin{cases} 1 & \text{if } T^{M_c} - \lambda \leq n_2 p_l^{M_c}, \\ \alpha & \text{if } n_2 p_l^{M_c} < T^{M_c} - \lambda \leq n_2 p_h^{M_c}. \end{cases}$$

The IC condition for cohort 1 can be written as  $n_1 H - (T^{M_c} - n_2 p_l^{M_c}) \geq \alpha(n_1 H - (T^{M_c} - n_2 p_h^{M_c}))$ .

**PROPOSITION 8.** *In the two-cohort model, the optimal menu strategy has a target of  $T^{M_c} = \max(n_1, n_2)p_l^{M_c} + \min(n_1, n_2)p_h^{M_c}$ , and an expected profit of  $\pi^{M_c} = \alpha(2 - \alpha)T^{M_c}$ , where*

- (i)  $p_h^{M_c} = \min(H, (1 - \alpha)(H - L)(n_1/n_2) + L)$  and  $p_l^{M_c} = L$ , if  $n_1 \geq n_2$ ;
- (ii)  $p_h^{M_c} = (1 - \alpha)H + \alpha L$  and  $p_l^{M_c} = L$ , if  $n_1 \leq n_2$ .

It can be shown that the optimality of the menu pricing strategy, as well as the intertemporal strategy, is sustained in parameter spaces similar to the base model. However, the two-cohort model extension leads to the following new insights:

(i) The menu pricing strategy requires that one of the two cohorts of buyers have high valuations. The creator should target the higher price toward the smaller cohort, thus reducing the effectiveness of the menu pricing strategy as a price discrimination mechanism.

(ii) If  $n_1 > n_2$ , the price  $p_h^{M_c}$  is higher, and the second cohort of buyers finds it harder to free ride on the contributions from the first cohort. The high price  $p_h^{M_c}$  increases in this case because the first cohort's surplus depends not only on individual surplus  $H - p_h^{M_c}$  but also on the portion of buyers contributing  $p_l^{M_c}$ . Because the first cohort is less sensitive to  $p_h^{M_c}$ , the creator increases the high price in the menu, which hurts the second cohort.

To summarize, in the above two subsections, the optimality of the menu pricing strategy, as well as the intertemporal strategy, is sustained in similar parameter spaces. Additional insights arise from the changed incentives to free ride on another cohort's contributions. A larger second cohort, or one whose product valuations are expected to be higher, could create greater free-riding incentives for the buyers in the first cohort, thus making it more challenging for the creator to discriminate among buyers through a menu strategy.

#### 4.4. Uncertainty in Number of Buyers

We now examine the implications of demand uncertainty. We first consider the possibility of no-show in one period, followed by an uncertain number of buyers in two cohorts.

**4.4.1. No-Shows.** Suppose that in the first period of the base model, buyer  $B_1$  arrives with probability  $\theta$ . Conditional on the arrival of buyer  $B_1$ , the IC condition of the menu strategy remains  $H - p_h^M \geq \alpha(H - p_l^M)$ , then the optimal menu prices are the same as in Lemma 1. Next, suppose that in the second period, buyer  $B_2$  arrives with probability  $\theta$ . In this case, the project may still fail even if buyer  $B_1$  has contributed  $p_h^M$ . The IC condition becomes  $\theta(H - p_h^M) \geq \alpha\theta(H - p_l^M)$ , which is equivalent to the original IC condition. Hence the optimal menu prices remain the same as in Lemma 1. In both cases, the project success rate and the creator's expected profit under the menu strategy shrinks by a factor of  $\theta$ . Because the profits under other pricing strategies are also reduced by the same factor  $\theta$ , the parameter spaces wherein each pricing strategy is optimal remain the same. Therefore the presence of demand uncertainty in the form of no-show does not change the main results obtained in the base model.

**4.4.2. Uncertain Number of Buyers and Overfunding.** To consider the uncertain number of buyers in a two-cohort model, we suppose that the number of buyers in the first period is a constant  $n_1$  and that the number of buyers in the second period  $N_2$  is random. Let  $N_2$  follow a two-point distribution: With probability  $\beta$ ,  $N_2 = n_2^H$ , and with probability  $1 - \beta$ ,  $N_2 = n_2^L$ . First consider the case wherein  $n_1 \leq n_2^L < n_2^H$ . Consistent with the base model, to induce a high-type first cohort to pay the high price to ensure success, the creator sets the target  $T^{M_o} = n_1 p_h^{M_o} + n_2^L p_l^{M_o}$  for a menu  $(p_l^{M_o}, p_h^{M_o})$ . Further assume that  $n_2^H$  is large enough such that even if the first cohort has low valuation and chooses to pay  $p_l^{M_o}$ , the project can succeed when  $N_2 = n_2^H$ , i.e.,  $(n_1 + n_2^H)p_l^{M_o} \geq T^{M_o}$ . Then, the IC condition for the first cohort is  $n_1(H - p_h^{M_o}) \geq (\alpha + (1 - \alpha)\beta)n_1(H - p_l^{M_o})$ , which yields the optimal pricing strategy  $p_h^{M_o} = (1 - \alpha)(1 - \beta)H + (\alpha + \beta - \alpha\beta)L$ ,  $p_l^{M_o} = L$ . When the first cohort has high valuation and  $N_2 = n_2^H$ , the creator collects  $n_1 p_h^{M_o} + n_2^H p_l^{M_o}$ , which exceeds the target  $T^{M_o}$ . Here the target is set ex ante and the first cohort makes pledge decisions before knowing the actual size of the second cohort. Overfunding occurs in equilibrium when the second cohort is large. The same phenomenon occurs for the case wherein  $n_2^L \leq n_1 \leq n_2^H$ , and the cases wherein the size of the first cohort is random (see the online appendix). Overfunding is commonly observed in crowdfunding. For example, among the 60 projects we tracked on Kickstarter, the creators on average collected 27% more than the targets.

The base model assumes that each buyer arrives at the site at an exogenously determined time and makes the sign-up decision on arrival. In reality, the buyer who arrives early may choose to postpone the

decision. If both buyers are fully informed of the posting, they may simultaneously choose their purchase times. We examine these two possibilities in §§4.5 and 4.6.

#### 4.5. Strategic Delay

Here we extend the base model by allowing buyer  $B_1$  to postpone the pledge decision, and analyze how her decision timing may affect the creator's optimal product and pricing strategy.

**PROPOSITION 9.** *In a sequential crowdfunding model allowing for strategic delay, the first buyer would make the sign-up decision in the first period. The optimal product and pricing decisions are identical to those in the base model.*

The underlying logic for the above proposition is as follows. First, a low-type buyer  $B_1$  is indifferent between waiting or making the decision immediately because the creator sets a price that fully extracts the surplus from such a buyer. Postponing the decision to the second period will not improve the expected surplus. To break the tie, we assume that a low-type buyer  $B_1$  always purchases at  $p_l^M = L$  in the first period.

Now consider a high-type buyer  $B_1$ . If this buyer chooses to postpone the purchase decision, in period 2 there will be two buyers in the market,  $B_1$  and  $B_2$ . In this simultaneous game of period 2, one may worry about the possibility that the high-type buyer  $B_1$  will choose the low option in the hope that another (high type) buyer chooses the high option. However, given the uncertainty about buyer  $B_2$ 's type, buyer  $B_1$  still faces the same trade-off between paying a high price for guaranteed success and paying a low price for an uncertain outcome. Moreover, the optimal menu is designed such that a high-type buyer is indifferent between choosing the high and low option. Hence, it is optimal for  $B_1$  to pay  $p_h^M$  in the second period. Even if  $B_1$  postpones the sign-up decision, the expected surplus is  $H - p_h^M$ , which is identical to the payoff from making the sign-up decision immediately in the first period. Therefore, a high-type buyer  $B_1$  should have no incentive to postpone the sign-up decision.

#### 4.6. Endogenous Arrivals

Now we further extend the base model by adding, before the two-period model, a period 0 when two buyers select an entry period. The sequence of events is as follows: (1) Buyers simultaneously decide which period to enter; (2) Buyer(s) entering in period 1 choose a price option; (3) Buyer(s) entering in period 2 observe decisions made in period 1 and choose a price option. Here we assume the creator adopts the optimal menu strategy specified in Lemma 1. (The general game of endogenizing the creator's pricing strategy followed by a three-stage game with endogenous

arrivals can be extremely complicated. As demonstrated below, the subgames may have multiple equilibria.) We limit our attention to a symmetric equilibrium wherein a buyer's strategy depends only on the buyer's type.

First, both types of buyers choosing to enter in period 2 is an equilibrium outcome. For low-type buyers, because their surpluses would be fully extracted, they are indifferent between entering in periods 1 and 2. Now consider a high-type buyer. Intuitively, regardless of the entry period chosen, she does not know the contribution made by the other buyer. Under the menu strategy, because the optimal menu is designed such that a high-type buyer is indifferent between the high and low options, the high-type buyer has no incentive to deviate and enter in period 1.

Next we consider other possible pure-strategy symmetric equilibria.

- Both low- and high-type buyers enter in period 1. This is not an equilibrium because a high-type buyer is always better off waiting until period 2. We fix one buyer who follows the strategy of always entering in period 1 and consider whether the other buyer has any incentive to deviate. A high-type buyer who enters in period 1 would optimally pay  $p_h^M$ , earning surplus  $H - p_h^M$ , because she cannot observe the contribution made by the other buyer who also enters in period 1. However, if she deviates to period 2, her expected surplus is higher at  $H - \alpha p_h^M - (1 - \alpha)p_l^M$ , because she can free ride when the other buyer in period 1 is a high type and has paid  $p_h^M$ .

- Low-type buyers enter in period 2 and high-type buyers enter in period 1. For the same reason stated above, this strategy is not an equilibrium.

- Low-type buyers enter in period 1 and high-type buyers enter in period 2. If no one pays in period 1, both buyers will know that the other buyer is a high type. Then in period 2, the only symmetric equilibrium is in mixed-strategies, with each high-type buyer choosing  $p_h^M$  with probability  $\gamma$  such that  $\gamma(H - p_l^M) = H - p_h^M$ . Solving this yields  $\gamma = \alpha$ . Therefore, each high-type buyer optimally chooses  $p_h^M$  with probability  $\alpha$  and  $p_l^M$  with probability  $1 - \alpha$ , which results in an expected surplus of  $H - p_h^M$ . If a high-type buyer deviates and enters in period 1, by the same analysis described above, the expected surplus is also  $H - p_h^M$ . Thus, high-type buyers are indifferent between deviating or not. This validates another equilibrium of endogenous sequencing.

In summary, there are two symmetric equilibrium strategies for the game with endogenous arrivals. In one equilibrium, both types of buyers enter in period 2. Here, the creator expects a higher profit than in the base model under the same menu strategy as specified in Lemma 1 (see the online appendix for a

full analysis of the simultaneous game and its comparison with the sequential game). In another equilibrium, low-type buyers enter in period 1 and high-type buyers enter in period 2. In this equilibrium, although the creator may be in a worse position than in the base model, he can still achieve higher profits than the optimal uniform strategies because a high-type buyer can be induced to pay the high price option  $p_h^M$  with some probability.

## 5. Conclusion

Crowdfunding is emerging as a popular platform from which thousands of entrepreneurs can raise initial funds and sell innovative products. This paper studies how this new business model may affect a creator's product and pricing decisions on the basis of a two-period game where cohorts of buyers arrive at a crowdfunding project and make sign-up decisions sequentially. Our results contribute some novel insights to the literature on product line design. In crowdfunding, even when product options are virtually the same, high-type buyers may still choose the high-price option. This result is unique to the crowdfunding mechanism as tacit coordination among buyers is necessary to ensure project success. Moreover, the incentive for a high-type buyer to coordinate with other buyers thusly is shaped by the creator's pricing decisions. When the value of the inferior option decreases, the high-type buyer's coordinating incentive diminishes. Our analysis also shows that the crowdfunding mechanism can change the optimal product line design. Compared with the traditional setting wherein a creator produces goods before selling to individual consumers, crowdfunding leads to a smaller product line quality gap.

This paper provides a number of considerations that will be useful to entrepreneurs interested in adopting the crowdfunding model and to crowdfunding platform managers. First, optimal product and pricing decisions should depend on market characteristics. Specifically, depending on the distribution of buyers' product valuations, a creator may choose a volume strategy, a margin strategy, an intertemporal strategy or a menu strategy. Second, when the market consists of a low or moderate fraction of high-type buyers and a moderate level of valuation heterogeneity, it is optimal to offer a menu of options. Product-line structure tends to be tighter with crowdfunding. Therefore, when an entrepreneur moves from the crowdfunding stage to large scale production and retailing, even if the market condition remains the same, the product line design should evolve. Third, creators should be cautious about any marketing activities that may change the mix of buyers arriving at the projects over time. The belief about the valuations of buyers who

arrive later has substantial implications for the sign-up behavior of early arrivals, as well as for the creator's product and pricing decisions. Under some conditions, the later arrival of a group of high-type buyers can encourage free riding.

Crowdfunding as an emerging area deserves more attention in future research. Theoretical analysis may investigate alternative mechanisms. For example, virtually all crowdfunding sites adopt the sequential mechanism. Alternatively, a creator may arrange for the buyers to make decisions simultaneously under which circumstance buyers do not know others' sign-up decisions. Our analysis indicates that the main results are similar in sequential and simultaneous situations. However, offering a menu of product options tends to be more profitable in the simultaneous than in the sequential setting. (Detailed analysis is available in the online appendix.) Another important crowdfunding feature is buyers' uncertainty about product quality, as well as about the creator, when pledge decisions are being made. Future research may investigate possible mechanisms to alleviate such information asymmetry. Empirical researchers should also find crowdfunding a fruitful area for future work. Many hypotheses can be generated from the existing literature in public economics and the current research on project designs and the dynamics of sign-up decisions. These hypotheses can be tested using a large number of projects that are posted online and publicly observed.

## Supplemental Material

Supplemental material to this paper is available at <http://dx.doi.org/10.1287/mksc.2014.0900>.

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## Appendix. Proofs.

**PROOF OF LEMMA 1.** Similar to the traditional product line design problem, the creator maximizes her profit when the IC condition is binding, and  $p_l^M = L$ . This gives that  $p_h^M = (1 - \alpha)H + \alpha L$ . Furthermore, the deal succeeds when at least one consumer has the high valuation, so the success rate is  $s^M = 1 - (1 - \alpha)^2 = \alpha(2 - \alpha)$ . The part on the profit function follows immediately.  $\square$

**PROOF OF PROPOSITION 1.** The results follow directly from comparing the profit functions.  $\square$

**PROOF OF COROLLARY 1.** Because all costs are zero in the base model, it suffices to consider the valuations of buyers served. With the margin strategy, the social welfare (W) is

$W^H = 2\alpha^2 H$ ; with the volume strategy, the welfare is  $W^L = 2(\alpha H + (1 - \alpha)L)$ ; with the intertemporal strategy the welfare is  $W^D = \alpha((1 + \alpha)H + (1 - \alpha)L)$ ; and under the menu strategy the welfare is  $W^M = \alpha(H + (1 - \alpha)L) + (1 - \alpha)\alpha(L + H)$ . A simple calculation yields that  $W^H < W^D < W^M < W^L$ . As for buyer surplus, denoted by  $CS$ , we have  $CS^L = 2\alpha(H - L)$ ,  $CS^H = 0$ ,  $CS^M = \alpha(H - L)$ , and  $CS^D = \alpha(H - L + H - p_h^M) + \alpha(1 - \alpha)(H - p_h^M)$  where  $p_h^M < H$ . We have  $CS^H < CS^D < CS^M < CS^L$ .

Without introducing the menu strategy, the volume strategy dominates whenever  $H/L \leq (2 - \alpha)/\alpha$ . Hence in the rest part  $H/L \geq (2 - \alpha)/\alpha$ , the menu strategy improves social welfare over the local optimal strategy. A similar argument holds for buyer surplus as well. The claim that the menu strategy is the dominating strategy when  $(2 - \alpha)/\alpha < H/L < (3 - \sqrt{5})/2$  or  $(2 - \alpha)/\alpha < H/L < (1 + \alpha - \alpha^2)/(3\alpha - \alpha^2 - 1)$  follows from Proposition 1.  $\square$

**PROOF OF PROPOSITION 3.** If  $H/L \leq 1/\alpha$ ,  $(Q_h^T - Q_l^T) - (Q_h^M - Q_l^M) = (\alpha^2(H - L))/(1 - \alpha) > 0$ . If  $1/\alpha \leq H/L < (1 + \alpha)/\alpha$ ,  $(Q_h^T - Q_l^T) - (Q_h^M - Q_l^M) = \Delta > 0$ . If  $H/L \geq (1 + \alpha)/\alpha$ ,  $(Q_h^T - Q_l^T) - (Q_h^M - Q_l^M) = 0$ .  $\square$

**PROOF OF LEMMA 3.** With the margin strategy, the creator charges high-type buyers their valuations, i.e.,  $P^H = HQ^H$ . His expected profit is  $\Pi^H = 2\alpha^2(HQ^H - (Q^H)^2/2)$ . Taking the first order derivative with respect to  $Q_M$  solves the problem.

With the volume strategy, the creator charges  $P^L = LQ^L$ , so that both buyers make purchases. Then  $\Pi^L = 2(LQ^L - (Q^L)^2/2)$ , whose maximum can be solved by the first order condition.

Last, let us consider the intertemporal strategy. The creator sells to high-type buyers in one period (and without loss of generality, let us suppose it is period 1), and to buyers of any type in the other period (period 2). In period 1, the creator prices at  $HQ_1^D$ , and in period 2 at  $LQ_2^D$ . Then his expected profit is  $\Pi^D = \alpha(HQ_1^D + LQ_2^D - (Q_1^D)^2/2 - (Q_2^D)^2/2)$ . Again, the first order conditions give us the solution.  $\square$

**PROOF OF PROPOSITION 4.** When product qualities are endogenized, the profits of various strategies are given in Proposition 2 and Lemma 3. The range in which a specific strategy dominates follows by comparing the profit functions.  $\square$

**PROOF OF LEMMA 4.** The IC condition is now  $\alpha_2 \cdot (H - p_l^{M_h}) \leq H - p_h^{M_h}$ , together with the individual rationality  $p_l^{M_h} \leq L$ . When both inequalities are binding, the creator maximizes her profit. The success rate is  $1 - (1 - \alpha_1) \cdot (1 - \alpha_2) = \alpha_1 + \alpha_2 - \alpha_1\alpha_2$ , and this proves the lemma.  $\square$

**PROOF OF COROLLARY 2.** Taking derivatives of  $\pi^{M_h}$  with respect to  $\alpha_1$  and  $\alpha_2$  yields that  $\partial \pi^{M_h} / \partial \alpha_1 = (1 - \alpha_2)^2 H + (1 - \alpha_2^2)L \geq 0$  and  $\partial \pi^{M_h} / \partial \alpha_2 = (1 - 2\alpha_1 - 2\alpha_2 + 2\alpha_1\alpha_2)H + L + 2(1 - \alpha_1)\alpha_2 L$ , which is no less than zero when  $\alpha_2 \leq (H - 2\alpha_1 H + L)/(2(1 - \alpha_1)(H - L))$ , and is less than zero otherwise.  $\square$

**PROOF OF PROPOSITION 8.** When  $n_1 \geq n_2$ ,  $T^{M_c} = n_1 p_h^{M_c} + n_2 p_l^{M_c}$  and the IC condition is  $n_1 H - n_1 p_l^{M_c} - n_2 p_h^{M_c} + n_2 p_l^{M_c} \geq \alpha n_1 (H - p_l^{M_c})$ . The creator maximizes her profit

when  $p_l^{M_c} = L$  and the IC condition is binding, which gives  $p_l^{M_c} = L$  and  $p_h^{M_c} = (1 - \alpha)(H - L)(H/L) + L$ . However, we need the additional constraint  $p_h^{M_c} \leq H$  here. Moreover, we have the success rate being  $\alpha(2 - \alpha)$ , and this proves the first part.

When  $n_1 \leq n_2$ ,  $T^{M_c} = n_1 p_l^{M_c} + n_2 p_h^{M_c}$ . The first cohort pays either  $n_1 p_h^{M_c}$  or  $n_1 p_l^{M_c}$ , but never anything between them. If the first cohort pays  $n_1 p_h^{M_c}$ , the conditional success rate is 1; if the first cohort pays within  $[n_1 p_l^{M_c}, n_1 p_h^{M_c})$ , the success rate is  $\alpha$ . The first cohort cannot pay less than  $n_1 p_l^{M_c}$  as long as  $p_l^{M_c} \leq L$ . Now the IC condition becomes  $n_1 H - n_1 p_h^{M_c} \geq \alpha(n_1 H - n_1 L)$ , and this immediately verifies the second part.  $\square$

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