Decision Support Systems 144 (2021) 113520

Contents lists available at ScienceDirect

Decision Support Systems

journal homepage: www.elsevier.com/locate/dss

Choice of pricing and marketing strategies in reward-based crowdfunding campaigns

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ARTICLE INFO

Keywords:
Crowdfunding
Sales scheme
Product pricing
Financial constraints

ABSTRACT

As a newly-emerged financing method, crowdfunding has been gaining popularity among entrepreneurs in recent years. Two major functions are featured in crowdfunding campaigns: financing and marketing. Focusing on reward-based crowdfunding campaigns that adopt the "All-or-Nothing" mechanism, this paper mainly investigates how entrepreneurs set their funding targets and sales strategies with two cases considered—one without and the other with financial constraints. In particular, entrepreneurs without financial constraints may concentrate on profit maximization via product marketing, while those with financial constraints may start with establishing funding targets to ensure the success of the campaign first, and then the retail of products. Two theoretical models are built—one with financial constraints and the other without financial constraints—to determine the optimal product price and sales scheme. We find that the consumers' perceived value of extra rewards and the probability of product matching both play a significant role in product price optimization and profit maximization. Without financial constraints, entrepreneurs' choices on sales schemes vary depending on the consumers' perceived value of extra rewards and the probability of product matching, whereas a two-stage sales scheme is optimal for entrepreneurs with financial constraints. Our results also reveal that a higher probability of product matching may benefit social welfare but damage consumer surplus under certain circumstances. Using real data from the Kickstarter platform, this paper offers a new perspective to enrich the understanding of theoretical results.

1. Introduction

Propelled by the rapid development of the Internet, crowdfunding (CF[1]) has become an important source of financing in recent years for start-ups or individuals to raise initial capital for product development and production. In practice, CF can be classified into four categories: donation-based, reward-based, lending and equity [1]. Reward-based CF has already become a popular way of funding products, allowing start-ups or individuals to motivate potential consumers to fund the campaigns in exchange for non-monetary rewards, which are, most often, products to be manufactured by these entrepreneurs.

As of June 2020, "Kickstarter", the biggest reward-based CF platform, has raised $5.0 billion with 182,749 successful funding campaigns.[2] Meanwhile, the primary goal of entrepreneurs is to raise sufficient capital for product development and production due to the "All-or-Nothing" mechanism adopted by Kickstarter [2]. CF has become a popular way for entrepreneurs to raise money, but CF platforms like Kickstarter are being increasingly used as marketing platforms [3]. In practice, some entrepreneurs may have a low funding target, while others may require outstanding technical competence and substantial funding, especially for design and technology campaigns [4]. Therefore, the financing and marketing roles of CF are incorporated into this paper according to the amount of the funding target. Similar to Belleflamme et al. [5], when the funding target is lower than a threshold, which is equal to the entrepreneur's optimal profit at the CF stage, it is acknowledged that entrepreneurs need a low funding target and are more concerned with the marketing role of CF in maximizing profits. This is referred to as "without financial constraints". In contrast, when the funding target is higher than this threshold, it is believed that entrepreneurs need a high funding target, with the financing role of CF being their top priority, and the marketing role is pursued only after attaining the funding target [6]. This is defined as "with financial

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[1] Crowdfunding is hereafter referred to as CF for convenience.

[2] Available at https://www.kickstarter.com/help/stats?ref=about_subnav.

https://doi.org/10.1016/j.dss.2021.113520
Received 25 June 2020; Received in revised form 3 January 2021; Accepted 6 February 2021
Available online 10 February 2021

constraints". Two campaigns are used to illustrate the typical funding and selling processes of the CF campaign.

For example, *Xeric Apollo 11 50th Anniversary Automatic Watch*[3] has been one of the most successful CF campaigns. The entrepreneur started a campaign on "Kickstarter" with detailed information, including the funding target, rewards, the CF price and the retail price. A two-stage sales strategy, which consists of CF and retailing, was adopted. Consumers, subsequently, decided whether to purchase the products based on the given information. On Kickstarter, if entrepreneurs fail to meet the funding target, all the capital will be refunded to the pledged consumers via the CF platform. If the funding target is met, however, entrepreneurs are expected to develop and produce the products and distribute them to the pledged consumers. Entrepreneurs can continue their sales in the retail market via an online platform, and consumers who have not already bought the products can make a purchasing decision based on product information and consumers' reviews. For another case, *Virtual competitions: Mobile app,*[4] some variations are shown compared with the campaign described above, which can be summarized as follows. A one-stage sales strategy, which only included CF, was adopted, instead of the above mentioned two-stage one. Consumers were only able to purchase the products through CF campaign. In both the two cases mentioned above, extra rewards and experiences are provided for the pledged consumers, e.g., freebies, consumer community benefits [5], and opportunities for interaction between consumers with entrepreneurs, etc. Consumers obtain the perceived value generated from the additional experiences, which is defined as the consumer's perceived value of extra rewards.

Based on the above discussion, it can be seen that the first campaign focused on a two-stage sales strategy, while the second campaign concentrated on a one-stage selling strategy. In a two-stage sales strategy, entrepreneurs always set the CF price lower than the retail price to motivate consumers to purchase their products early on. However, this increasing pricing plan cannot extract higher surplus from the high-valued consumers in the CF campaign, and an increase in the retail price may lead to a reduction of consumer demands. Therefore, it is not certain whether the optimal sales scheme and product pricing vary under different scenarios. In addition, such information is obtained through practice that most entrepreneurs were able to raise no more than $10,000, whereas a small yet growing proportion of entrepreneurs were able to raise six, seven or even eight figures.[5] Compared to entrepreneurs without financial constraints, those with financial constraints need to set a high funding target to develop and produce products and have to balance between raising a higher target and reaching it. Due to the reasons above, we attempt to explore how these two types of entrepreneurs—one with and the other without financial constraints—formulate the optimal product price and sales scheme in CF and analyse the impact of financial constraints on entrepreneurs' decision-making.

In particular, the main research questions in this paper are as follows. First, for entrepreneurs without financial constraints, who focus more on the marketing role of CF, we investigate what kind of sales scheme the entrepreneur should adopt, with consideration of both a one-stage sales scheme and a two-stage one. We also attempt to study how to design optimal product prices to maximize profits in these two different sales strategies. Second, the impact of entrepreneurs' decisions on consumer surplus and social welfare is examined. Finally, for entrepreneurs with financial constraints whose first consideration lies in financing, followed by marketing, studies are conducted on how they set funding targets and adjust product prices and sales strategies. The optimal prices in the financial constraints setting are evaluated, with the comparison to those without financial constraints.

To answer the questions above, a two-period CF is considered. To investigate the optimal product price and sales strategy in different cases, we mainly discuss CF campaigns with business attributes, which usually deliver concrete products [7]. Note that new products are still prototypes, or even being developed during the CF period, and consumers cannot accurately estimate the probability of the match between the products and their needs. Combining online product descriptions with their personal information, consumers have an assessment on their probability of the match to the products [8]. In this paper, we use the probability of product matching to reflect the likelihood of the match between consumer needs and the products. Particularly, consumers who purchase the product in the CF campaign may incur regret costs when they fail to receive the desired product. At the retail stage, we assume that no regret cost is generated because consumers can learn about product performance through consumer reviews or other means. A notorious example as far as we know is *Zano*, which provided extra rewards for the pledged consumers and successfully raised £2.3 million from the Kickstarter platform. However, *Zano*'s entrepreneurs were not able to deliver rewards to all pledged consumers before declaring bankruptcy due to technical challenges [9]. Based on the above description, we formulate the expected profit function of entrepreneurs and derive optimal product prices, pricing plan and entrepreneurs' profit in the two sales strategies. Moreover, different conclusions are drawn in comparing and analysing the two cases—one with and the other without consideration of financial constraints.

The analysis yields several main insights, as follows. First, a theoretic model built to describe entrepreneurs' profits shows that either a one-stage sales scheme or a two-stage one may be the optimal choice for entrepreneurs without financial constraints. With financial constraints, however, entrepreneurs should adopt a two-stage sales scheme. Second, entrepreneurs without financial constraints aim at product marketing and profit maximization, while those with financial constraints focus more on the financing role of the CF, and they should first set an appropriate funding target to ensure the success of CF campaigns and then sell the products at the retail stage. Third, we discover that the probability of product matching has an important influence on the pricing plan. To be specific, if the probability of product matching is low, entrepreneurs will announce an increasing pricing plan; otherwise, a decreasing pricing plan is preferred. With financial constraints, entrepreneurs are more inclined to set a discounted CF price and opt for an increasing pricing plan. Finally, it is also shown that a higher probability of product matching may benefit social welfare but damage consumer surplus under certain cases.

The remaining sections of this paper are organized as follows: In Section 2, a study of related literature is presented. In Sections 3 and 4 two models—one with and the other without consideration of financial constraints—are built, and theoretical results are derived. Section 5 depicts the descriptive statistics of real data collected from Kickstarter. Section 6 summarizes the conclusions and limitations. All proofs are provided in the Appendix.

2. Literature review

A relatively new financing method as CF is for start-ups or individuals, the rise and rapid expansion of numerous CF platforms has attracted increasing attention in recent years from many researchers and entrepreneurs interested in CF campaigns. The CF campaign is analogous to advance selling to some degree in that consumers are encouraged to engage in the CF campaign before the product is released [10]; for this reason, the literature in advance selling is reviewed first.

The main benefits of advance selling are to reduce the risk of demand uncertainty in retailing and help entrepreneurs make optimal inventory decisions or capacity allocations [11,12]. Noparumpa et al. [13] studied how the barrel score and consumer heterogeneity affect the

[3] Available at https://www.kickstarter.com/projects/watchismo/xeric-nasa-trappist-1-automatic-watch/comments.

[4] Available at https://www.kickstarter.com/projects/goldcoastleague/virtual-competitions-mobile-app?ref=discovery_category_newest

[5] Available at https://www.kickstarter.com/help/stats?ref=about_subnav.

winemaker's capacity allocation and pricing decisions during futures and retail periods. Yu et al. [14] demonstrated that the interaction between capacity and consumer value played an important role in the two stages of advance selling and retail. Huang et al. [15] examined how pricing and production quantity strategies were affected by pre-sale capabilities and freebies. Unlike these analytical researches that analysed the different aspects of the capacity allocation and pricing decisions for the two-stage sales activity, this research investigates entrepreneurs' sales scheme choice and pricing decisions based on both one-stage and two-stage sales schemes. Moreover, the main function of advance selling activities is product marketing; however, the main functions of CF include product financing and marketing [6].

The closest theoretical work to ours is the product sales strategy choice studied by Prasad et al. [11] and Ma et al. [16]. A study on product sales strategy choice, in which a two-period model was established to study whether retailers should employ advance selling to transfer some uncertain risks to consumers, and it was suggested that advance selling was not always optimal for retailers [11]. Ma et al. [16] investigated whether manufacturers should provide advance selling programmes, and came to the conclusion that advance selling programmes should only be adopted under specific circumstances. Different from the selection of entrepreneurs' sales strategies in advance selling activities, entrepreneurs who initiate CF campaigns have a small amount of capital, but not enough to develop products. They are unable to obtain capital through traditional financing channels, and achieving the funding target is the only way for them to realize the successful launch of products. Therefore, we pay special attention to whether entrepreneurs should continue to sell products in the retail market after reaching the funding target. Our model differs from the advance selling model in regard to several key factors, including entrepreneurs' financing demand, the "All-or-Nothing" mechanism and consumers' valuation of the extra rewards, all of which are rarely considered in the advance selling model but are important characteristics of the CF campaign. We incorporate these features into the CF model in this study. The following part is a detailed description of relevant research on CF.

In practice, most of the research in the CF field is empirical [17–19]. Most empirical research on reward-based CF focused on the funders' behaviour and the campaign attributes that affected the success rate, e.g., the funding target [18], the pledge patterns of backers [20], the duration of the campaign [21,22]. In terms of theoretical model research, some studies centred on the approaches to improve the success rate of CF campaigns. Alaei et al. [23] explored how firms maximized their chance of success by designing product prices and funding targets. Du et al. [24] proposed that entrepreneurs implement three contingent stimulus policies in the middle of the CF campaign, which can turn the underperforming CF campaigns from failure to success. Yang et al. [25] investigated how firms maximized the success rate of campaigns by designing the profit allocation mechanism, suggesting that providing consumers with a reasonable profit allocation mechanism could increase the success rate. Moreover, some researchers studied the financing features of CF, such as the choice of funding mechanisms [26,27], financing source selection [4,6,28], moral hazards [29,9,30] and information asymmetry [31,32]. In addition to the success rate and financing features, or financing role, of CF, entrepreneurs are also concerned with the marketing decisions about consumers' behaviour and campaign characteristics, such as sales scheme and product delivery, which are also considered in this research. However, existing studies are insufficient in their investigation in terms of the pricing and sales strategies of reward-based CF campaigns, especially when they are combined with marketing characteristics of CF. There are only a few papers have studied the pricing strategy based on the financing role as follows.

Hu et al. [33] proposed a two-period model to compare four pricing strategies and demonstrated that entrepreneurs should provide a menu pricing strategy under certain conditions. Guan et al. [34] compared the optimal pricing strategies in two cases, one with and one without consideration of advertising investment, based on a two-stage sales scheme. Bender et al. [2] discussed how entrepreneurs could use CF as a vehicle for price discrimination to extract higher surplus. Sayedi and Baghaie [3] studied the optimal conditions of CF as a price discrimination tool. The aforementioned literature focused more on entrepreneurs' pricing decisions based on the financing role of CF. It is believed that product pricing, the key factor to ensure sufficient funding, requires careful thinking on entrepreneurs' behalf. With the development of CF, it is increasingly understood as a campaign with business attributes, choosing an appropriate sales scheme as a marketing strategy is also vital to entrepreneurs' profits. Hence, both the marketing and financing roles of CF are discussed in this study with two cases involved, one with and the other without financial constraints. And we study the optimal product prices and sales scheme selection in both cases.

The closest work to our paper is that of Belleflamme et al. [5], and the important differences and theoretical contributions of our paper are summarized below. First, Belleflamme et al. [5] compared two CF financing mechanisms of pre-ordering and profit sharing by building a two-stage game. However, to the best of our knowledge, our paper is one of the few studies that develop generalized models to examine the dual role of CF as a funding channel as well as a marketing tool for selling products by considering two cases, one with and the other without financial constraints. Our results guide entrepreneurs on how to implement optimal product prices and sales schemes in the above two cases. Second, we differ from prior research on the success rate of CF by investigating how entrepreneurs set an appropriate funding target. A relationship between the funding target and financial constraints is revealed. Compared with no financial constraints, entrepreneurs with financial constraints have to set funding targets more carefully. Additionally, two cases from the perspectives of both the product price and the sales scheme are analysed, with results showing that for entrepreneurs both with and without financial constraints, different product price and sales scheme may be preferable. Third, using real data from the Kickstarter platform, a new perspective is offered to enrich the understanding of theoretical results, which was not considered by Belleflamme et al. [5].

3. Basic model and analysis without financial constraints

This section involves the discussion on reward-based CF, in which a risk-neutral entrepreneur launches a CF campaign and posts its detailed information, including funding target T, CF price p_1 and retail price p_2. Meanwhile, the entrepreneur needs to decide on a sales scheme for products and announce all the rewards that the pledged consumers can receive. Regardless of financial constraints, the CF campaign can be guaranteed success by setting a funding target less than or equal to the entrepreneur's maximum profit. At the beginning of the campaign, consumers log on to the platform to browse product information and make purchasing decisions, and entrepreneurs will develop and produce products and distribute them to consumers if the funding target is reached. Subsequently, the entrepreneurs who decide to implement a two-stage sales strategy would further sell products in the retail market. At this point, consumers who have not purchased the products will make purchasing decisions.

Despite the fact that most platforms allow entrepreneurs to provide consumers with a menu of prices [33], we make a simplified assumption that there is only one CF price p_1 in our model and that each pledged consumer will receive a unified product if the funding target is met. To focus on the sales strategy in the model, we make the following assumptions: (i) Entrepreneurs who raise capital through CF platforms have no or only a little private capital and cannot raise capital through traditional financing channels, such as venture capital and bank loans (see, e.g., [2,5]). (ii) At the CF stage, consumers cannot exactly estimate the probability of the matching between the product and their needs [9], and we define α as the probability of product matching, which affects consumers' purchasing decisions. Furthermore, when consumers receive products that do not match their needs, regret costs η may appear [26].

(iii) Consumers should do their best to ensure the success of the campaign, so they may be willing to purchase the products as long as their expected utility is non-negative [23]. This assumption is consistent with the facts. If the funding target is not met by the deadline, the entrepreneurs will not be able to obtain capital from the platform, and the consumers will not be able to experience the products. Thus, both consumers and entrepreneurs are eager to reach the funding target through their joint efforts. Moreover, the pledged consumers can obtain additional value from the extra rewards, $\theta$is assigned to denote the consumer's perceived value of the extra rewards. Table 1 summarizes the notations.

3.1. The consumer

With product description, CF price$p_1$and retail pricep_2, consumers make purchasing decisions based on the expected utility. At the CF stage, consumers want to do their best to help entrepreneurs reach the funding target. Despite the risk of regret cost, consumers are willing to purchase the products because of the extra rewards offered by entrepreneurs [5]. Therefore, the purchase will happen if consumers' expected utility is non-negative. Each consumer's expected utility in the CF campaign can be donated as

$$EU_1 = \alpha(v - p_1 + \theta) - (1-\alpha)\eta \tag{1}$$

It is found that if the CF price exceeds a certain valuep_0, where$p_0 = 1 - (1-\alpha)\eta/\alpha + \theta$, few consumers can afford it, which means that if the CF price exceedsp_0, the entrepreneur will not be able to obtain the required capital through any financing channels. Therefore, we assume that$p_1 < p_0$in this paper. When$p_1 < p_0$, the existence of a thresholdv_0, where$v_0 = (1-\alpha)\eta/\alpha + p_1 - \theta$, is evident, and consumers would purchase the product if their valuation$v$exceeds this thresholdv_0.

Subsequently, the products will be mass produced and sold in the retail market if the funding target is met in a two-stage sales strategy. At the retail stage, regret cost will not occur, nor will extra rewards, leaving the remaining consumers with a purchasing decision—they will purchase the product only if their private valuation is higher than the retail price. Each consumer's utility at the retail stage can be formulated as follows:

$$EU_2 = v - p_2. \tag{2}$$

However, consumers who have not purchased the products have to leave the market in the one-stage sales strategy because entrepreneurs only serve pledged consumers. This means that the consumer's utility at the retail stage is zero in a one-stage sales scheme.

Table 1
Definition of the notations.

Symbol	Description
j(=*one*, *two*)	Index for scenarios of the one-stage and two-stage selling schemes
$i = (1,2)$	Index for the stage of the campaign
co	Index for cases with financial constraints
v	Consumer valuation of the product, which follows the uniform distribution of $[0,1]$, and the probability density function is $f(v)$
α	Probability of product matching, $0 \le \alpha \le 1$
θ	Consumers' perceived value of extra rewards, $0 \le \theta \le 1$
η	Regret cost, $0 \le \eta \le 1$
c	A unit production cost, $0 \le c \le 1$
T	The funding target
p_i^j	The unit price at stage$i$under scenario$j$
p_i^{co}	The unit price at stage$i$under the caseco
d_i^j	The product demand at stage$i$under scenario$j$
d_i^{co}	The product demand at stage$i$under the caseco
π_j	Entrepreneur's profit under scenario$j$
π_i^{co}	Entrepreneur's profit at stage$i$in the caseco
π^{co}	The total entrepreneur's profit in the caseco
EU_i	The consumer's expected utility at stage$i$
CS_i^j	The consumer surplus at stage$i$under scenario$j$
SW_j	Total social welfare under scenario$j$

3.2. The entrepreneur

When a CF campaign is launched, the funding target, two-stage product prices and sales scheme should be determined simultaneously. Meanwhile, the entrepreneur should make the strategic choice in regard to consumers' rewards and extra rewards that consumers could receive after the funding target is met. Without loss of generality, consumers' rewards are related to the final product. Moreover, extra rewards provided by the entrepreneurs to the pledged consumers are usually non-pecuniary or relatively inexpensive. Therefore, we ignore the cost of extra rewards, and the entrepreneurs only incur a unit production cost$c$. The entrepreneurs who adopt a two-stage sales scheme will continue to sell products in the retail market if the funding target is met.

From the aforementioned introduction, we can find that the different optimal profits and product prices are obtained when entrepreneurs implement different sales schemes. The best sales scheme can be selected by comparing the profits generated by each scheme. Based on the above description, the expected profit of the entrepreneur in a two-stage sales scheme can be expressed as

$$\pi_{two} = \left(p_1^{two} - c\right)d_1^{two} + \left(p_2^{two} - c\right)d_2^{two}, \tag{3}$$

where$d_1^{two} = 1 - ((1-\alpha)\eta/\alpha + p_1^{two} - \theta)andd_2^{two} = ((1-\alpha)\eta/\alpha + p_1^{two} - \theta - p_2^{two})^+$represent the demand in the CF stage and the retail stage respectively. And the expected profit of the entrepreneur in a one-stage sales scheme can be expressed as

$$\pi_{one} = \left(p_1^{one} - c\right)d_1^{one}, \tag{4}$$

where$d_1^{one} = 1 - ((1-\alpha)\eta/\alpha + p_1^{one} - \theta)$represents the total demand. And a graphical illustration of the sequence of events is given in Fig. 1.

3.3. Analysis of the selling schemes and pricing plans of the entrepreneurs

One of the most vital steps for the entrepreneur is to determine an appropriate sales scheme and product price. From the expression of the entrepreneur's profit function, we derive that the entrepreneur's profit is a strictly concave function of the CF price and the retail price. By taking the partial derivative of the profit function with respect to the CF price and the retail price, we find that the optimal price has a unique solution and derive the optimal prices$p_1^{two}{}^*$,$p_2^{two}{}^*$and$p_1^{one}{}^*$in two sales schemes. We further analyse how the optimal price and profit vary with the parametersαandθin the following proposition.

Proposition 1. The optimal price and the corresponding entrepreneur's expected profit in the two sales schemes are as follows:

$$p_1^{two}{}^* = (2 - (1-\alpha)\eta/\alpha + \theta + c)/3, p_2^{two}{}^* = (1 + (1-\alpha)\eta/\alpha - \theta + 2c)/3,$$
$$\pi_{two}^* = ((2 - (1-\alpha)\eta/\alpha + \theta - 2c)(1 - 2(1-\alpha)\eta/\alpha + 2\theta - c)) /9 + \left(((1-\alpha)\eta/\alpha + 1 - \theta - c)^2\right)/9$$
$$;p_1^{one}{}^* = (1 - (1-\alpha)\eta/\alpha + \theta + c)/2; \pi_{one}{}^* = ((1 - (1-\alpha)\eta/\alpha + \theta - c)^2)/4.$$
$$p_1^{two^*} - p_1^{one^*} = (1 - c + (1-\alpha)\eta/\alpha - \theta)/6$$

It is evident that $p_1^{two}{}^*$and $p_1^{one}{}^*$ ($p_2^{two}{}^*$) are increasing (decreasing) in $\alpha$and θ, and that $\pi_{one}{}^*$ is also increasing in $\alpha$and θ. However, $\pi_{two}{}^*$ is increasing in $\alpha$and $\theta$when $\alpha \ge 2\eta/(1 - c + 2\theta + 2\eta)$. Otherwise, it is decreasing in $\alpha$and θ. It is also revealed that $p_1^{two}{}^* > p_1^{one}{}^*$ is constant and the difference between them decreases as α increases. (The proof is the same as the proof for Proposition 8).

In a two-stage sales scheme, the CF price increases, but the retail price decreases as the consumers' perceived value of extra rewards and the probability of product matching increases. At the CF stage, the more extra rewards consumers receive, the higher the consumers' perceived value of the extra rewards; additionally, the more confidence the

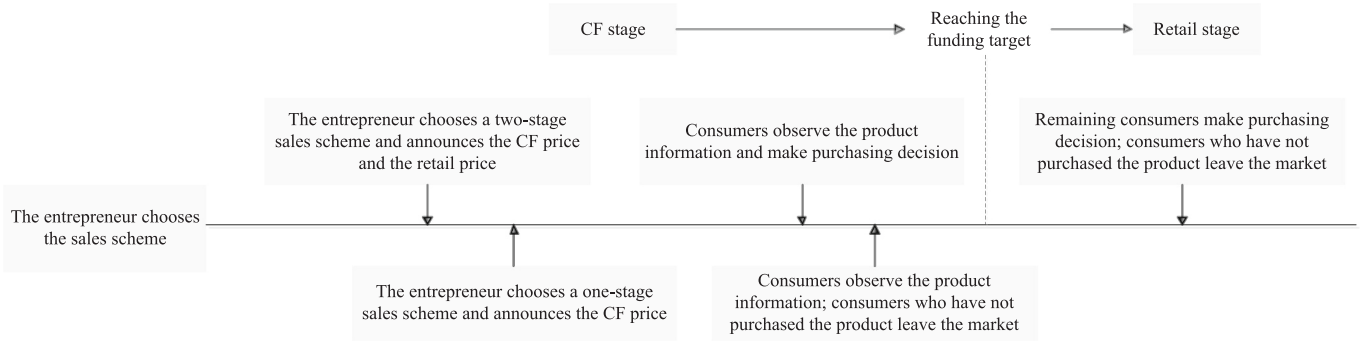

Fig. 1. Sequence of events.

consumers have in the product, the more likely it is they will meet the consumers' needs. Therefore, as the consumers' perceived value of extra rewards and the probability of product matching increase, consumers are more willing to purchase the products as early recipients and less sensitive to changes in the CF price, allowing entrepreneurs to have an incentive to extract higher surplus from their high-valued consumers by increasing the CF price. At the retail stage, as consumers' perceived value of extra rewards and the probability of product matching increase, a growing number of high-valued consumers are inclined to purchase the products in the CF campaign, and only a few low-valued consumers remain in the retail market. Therefore, entrepreneurs have to lower the retail price to provide more purchasing opportunities to further promote the product market.

We find that the probability of product matching and the consumers' perceived value of extra rewards have a non-monotonic effect on the entrepreneur's profits. Regardless of the probability of product matching, the entrepreneur will increase the CF price if the probability of product matching and the consumers' perceived value of the extra rewards increases. When the probability of product matching is high, consumers are less likely to incur regret costs, thus revealing a strong desire to purchase the product, allowing the entrepreneur to increase the CF price to obtain more profits. The entrepreneur's profit increases with the probability of product matching and the consumers' perceived value of the extra rewards. When the probability of product matching is low, consumers will be reluctant to purchase the products even if the probability of product matching increases because some of them have to give up purchasing as the CF price increases. The increase in profit from the increasing price cannot make up for the loss of consumer demand, the entrepreneur's profit decreases as the probability of product matching increases.

In a one-stage sales scheme, as the probability of product matching and the consumers' perceived value of extra rewards increases, the entrepreneur's profit increases. The increase in the product price has little impact on consumer purchasing intention because consumers can only purchase the products in the CF campaign. Thus, entrepreneurs can enhance profits by increasing the product price. Note that entrepreneurs are always willing to offer a discounted price to attract more consumers and abandon the needs of a few low-valued consumers in the one-stage sales scheme. When the probability of product matching is high enough, the CF price in the one-stage sales scheme can be slightly lower than that in the two-stage sales scheme. In the next part, entrepreneurs' optimal pricing plan in a two-stage sales scheme is summarized.

Proposition 2. Given p_1^{two*} and p_2^{two*}, the entrepreneur can announce an increasing price plan (i.e. $p_1^{two*} < p_2^{two*}$) when $\alpha \le 2\eta/(1 - c + 2\theta + 2\eta)$; otherwise, the entrepreneur can choose a decreasing price plan (i.e. $p_1^{two*} \ge p_2^{two*}$).

Proposition 2 indicates that entrepreneurs will adopt an increasing pricing plan if the probability of product matching is low. Otherwise, they prefer a decreasing pricing plan. In fact, when the probability of product matching is low, entrepreneurs have an incentive to offer consumers a discounted CF price to compensate for the loss caused by the mismatch between the product and consumer needs. The discounted price encourages more consumers to purchase the products to ensure that the funding target can be meet. Then, the entrepreneurs produce products and put them into the retail market, where consumers can observe and fully understand the products through consumer reviews. Because consumers will purchase products as long as their valuation exceeds the retail price, entrepreneurs can set a higher retail price to extract more surpluses to boost their profits. However, when the probability of product matching is high, consumers have a strong desire to purchase the products in the CF campaign because they can obtain extra rewards. At this time, entrepreneurs impose price discrimination and set a premium price to extract more surpluses from high-valued consumers and offer a low retail price to low-valued consumers at the retail stage.

Systematic comparison of the two sales schemes is then made from the perspective of entrepreneurs' profit, revealing the superior one for entrepreneurs to choose. Provided that $\Delta\pi = \pi_{two}^* - \pi_{one}^*$ is defined as the profit difference between the two sales schemes, and then we derive that

$$\begin{aligned}\Delta\pi &= \pi_{two}^* - \pi_{one}^* \\ &= ((2 - (1-\alpha)\eta/\alpha + \theta - 2c)(1 - 2(1-\alpha)\eta/\alpha + 2\theta - c))/9 \\ &+ ((1-\alpha)\eta/\alpha + 1 - \theta - c)^2 \Big/ 9 - \Big((1 - (1-\alpha)\eta/\alpha + \theta - c)^2\Big) \Big/ 4\end{aligned} \tag{5}$$

Proposition 3. Given $\Delta\pi$, when $\alpha \ge \eta/\left(\sqrt{3/7}\,(1+c) + \eta\right)$, entrepreneurs should prefer a two-stage sales scheme to a one-stage one; when $\alpha < \eta/\left(\sqrt{3/7}\,(1+c) + \eta\right)$, the choice of the optimal sales scheme depends on θ. In particular, entrepreneurs adopt a two-stage sales scheme if $\theta \le \theta_1$, while a one-stage sales scheme should be implemented if $\theta_1 < \theta \le \min(\theta_2, 1)$.

This paper focuses on obtaining the optimal sales scheme for entrepreneurs by comparing the profits of the two sales schemes. We point out that when the probability of product matching is high, entrepreneurs can use price discrimination in two-stage selling schemes to extract higher surplus from high-valued consumers and provide more purchasing opportunities for low-valued consumers to maximize profits. Nevertheless, when the probability of product matching is low, the optimal sales scheme is determined by the consumers' perceived value of extra rewards. Consumers, despite the low probability of product matching, are still willing to purchase the products at the CF stage if they deem the value of the extra rewards high, thus allowing entrepreneurs to obtain enough profits from the CF campaign, making the one-stage sales scheme the preferable one. However, once the consumers' perceived value of the extra rewards is low, most are reluctant to purchase prematurely. Therefore, it is optimal for entrepreneurs to adopt a two-stage sales scheme with a lower CF price to encourage purchasing, followed by

a higher retail price for more profits.

3.4. Analysis of consumer surplus and social welfare

This section, shifting our focus onto consumers, explores the impact of entrepreneurs' decisions on consumer surplus and social welfare. To be specific, consumer surplus is measured by the economic welfare that consumers gain from purchasing products; and social welfare is defined as the sum of consumer surplus and firm profit [6]. Consumer surplus and social welfare in the two sales schemes are presented below:

The consumer surplus at each stage and total consumer surplus are as follows:

$$CS_1^{two} = \int_{(1-\alpha)\eta/\alpha + p_1^{two} - \theta}^{1} (v - p_1^{two}) f(v) dv \tag{6}$$

$$CS_2^{two} = \int_{p_2^{two}}^{1} (v - p_2^{two}) f(v) dv \tag{7}$$

$$CS_{two} = CS_1^{two} + CS_2^{two}, \tag{8}$$

where$f(v)$represents the probability density function of the consumer's product valuation. And the total social welfare is given by

$$SW_{two} = CS_{two} + \pi_{two}^{*}. \tag{9}$$

In the same way, the total consumer surplus and social welfare in the one-stage sales scheme can be expressed as follows:

$$CS_{one} = \int_{(1-\alpha)\eta/\alpha + p_1^{one} - \theta}^{1} (v - p_1^{one}) f(v) dv \tag{10}$$

$$SW_{one} = CS_{one} + \pi_{one}^{*}. \tag{11}$$

We substitute$p_1^{two}*$,$p_2^{two}*$and$p_1^{one}*$ into Eq. (6) to Eq. (11) in sequence, and use the following proposition to explain the impact of consumers' perceived value of extra rewards and the probability of product matching on consumer surplus and social welfare.

Proposition 4. In a two-stage sales scheme, $CS_1^{two}$and$CS_{two}$are decreasing inαandθ, but$CS_2^{two}$is increasing inαandθ. When$\alpha > 4\eta/(-1 + 4\theta - 2c + 4\eta)$, $SW_{two}$is increasing in$\alpha$and vice versa. In a one-stage sales scheme, $CS_{one}$is decreasing inαandθ. When$\alpha > 4\eta/(-1 + 2\theta - 2c + 2\eta)$, $SW_{one}$is increasing in$\alpha$and vice versa.

Proposition 4 reveals that consumers' perceived value of extra rewards and the probability of product matching have a monotonic effect on consumer surplus. At the CF stage, consumers can benefit from extra rewards, and consumer support is critical for entrepreneurs to meet the funding target. The higher consumers' perceived value of extra rewards becomes, the more likely it is of an early purchase. Moreover, entrepreneurs can set a higher CF price to extract more surpluses from early consumers, resulting in a reduction in consumer surplus. At the retail stage, entrepreneurs should offer more purchasing opportunities to low-valued consumers by setting a lower price and extracting fewer surpluses so that the consumer surplus increases. We also find that the CF campaign has unique characteristics that are different from other sales activities and that it occupies a dominant position in a two-stage sales scheme. Therefore, changes in consumers' perceived value of extra rewards and the probability of product matching have the same effect on consumer surplus at the CF stage and total consumer surplus.

In proposition 4, we also demonstrate that consumers' perceived value of extra rewards and the probability of product matching have a non-monotonic effect on social welfare. In particular, when the probability of product matching is high, as consumers' perceived value of extra rewards and the probability of product matching increases, entrepreneurs raise the CF price and lower the retail price, resulting in an increase in profits far exceeding the reduction in consumer surplus, thereby increasing social welfare. However, when the probability of product matching is low, consumers' willingness to purchase products is significantly reduced because of the high risk of the mismatch. The increase in profits caused by product price adjustment cannot compensate for the decrease in consumer surplus, thus reducing social welfare as a result. With the probability of product matching changing from low to high, changes in consumer surplus and social welfare in a one-stage sales scheme are similar to those in a two-stage one.

4. Model and analysis with financial constraints

The aforementioned study explores the scenarios with entrepreneurs without financial constraints and their goals in marketing and profit maximization. However, some entrepreneurs require more capital and thus have financial constraints, so they have to first guarantee meeting the funding target and then consider product marketing. In this part, the financing role of CF in combination with financial constraints is analysed, following the study of the marketing role of CF in Section 3. We find that the optimal product price set by entrepreneurs to maximize profit cannot meet the funding target with financial constraints, namely$T > (p_1^* - c)(1 - ((1-\alpha)\eta/\alpha + p_1^* - \theta)) = \overline{T}$. Entrepreneurs have to adjust product prices and set reasonable funding targets to ensure the success of the campaign. Therefore, we investigate how entrepreneurs with financial constraints set optimal funding targets and adjust sales strategies and pricing plans.

4.1. The model

Similar to the case without financial constraints, consumers will purchase products if their expected utility is non-negative, namely$v \geq (1 - \alpha)\eta/\alpha + p_1^{co} - \theta$. Moreover, the entrepreneur's profit at the CF stage should be equal to the actual funding needed. The entrepreneur's profit at the CF stage can be expressed as

$$\pi_1^{co} = (p_1^{co} - c) d_1^{co}, \tag{12}$$

where$d_1^{co} = 1 - ((1 - \alpha)\eta/\alpha + p_1^{co} - \theta)$represents the demand in the CF stage. And the conditions for entrepreneurs to reach the funding target at the end of the CF campaign can be described as

$$\pi_1^{co} = (p_1^{co} - c) d_1^{co} \geq T. \tag{13}$$

According to the above inequality, we have that.

$-(p_1^{co})^2 + (1 + c - (1 - \alpha)\eta/\alpha + \theta)p_1^{co} + c((1 - \alpha)\eta/\alpha - \theta - 1) - T \geq 0$. We first derive that$\Delta = (1 + c - (1 - \alpha)\eta/\alpha + \theta)^2 + 4(c((1 - \alpha)\eta/\alpha - \theta - 1) - T)$, and the above inequality has the solution when$\Delta \geq 0$. We find that the CF campaign will succeed only if entrepreneurs set the funding target within a reasonable range, namely$\overline{T} < T \leq c((1-\alpha)\eta/\alpha - \theta - 1) + (1 + c - (1 - \alpha)\eta/\alpha + \theta)^2/4 = \widetilde{T}$. Moreover, according to the root-finding formula, we have that:

$$p_1^{+} = \left((1 + c - (1-\alpha)\eta/\alpha + \theta) + \sqrt{\Delta}\right)/2;$$

$$p_1^{-} = \left((1 + c - (1-\alpha)\eta/\alpha + \theta) - \sqrt{\Delta}\right)/2$$

.

With financial constraints, even if entrepreneurs adopt different sales schemes, their profits in the CF stage are the same, which are equal to the funding actually needed. In order to gain more profit and expand the product market, entrepreneurs always prefer a two-stage sales scheme. At the retail stage, the remaining consumers make purchasing decisions, and each consumer will purchase the products if their private valuation is higher than the retail price. Therefore, the entrepreneurs' profit at the retail stage can be expressed as

$$\pi_2^{co} = (p_2^{co} - c) d_2^{co}, \tag{14}$$

where$d_2^{co} = (1 - \alpha)\eta/\alpha + p_1^{co}* - \theta - p_2^{co}$represents the demand in the

retail market. It is easy to see that the entrepreneur's profit at the retail stage increases with the CF price according to the above Eq. (14). Thus, entrepreneurs should set a higher CF price (p_1^+) to maximize profits under the premise of ensuring that they can meet the funding target. Then, we can derive that the optimal CF price and retail price are.

$p_1^{co^*} = \left((1+c-(1-\alpha)\eta/\alpha+\theta)+\sqrt{\Delta}\right)/2; p_2^{co}* = ((1-\alpha)\eta/\alpha + p_1^{co}* - \theta + c)/2.$

$$\begin{aligned}\pi^{co} &= \pi_1^{co} + \pi_2^{co} \\ &= \left(p_1^{co^*} - c\right)\left(1 - \left((1-\alpha)\eta/\alpha + p_1^{co^*} - \theta\right)\right) + \left((1-\alpha)\eta/\alpha + p_1^{co^*} - \theta - c\right)^2 \Big/ 4.\end{aligned} \tag{15}$$

Finally, the total profit function of entrepreneurs can be obtained as follows:

4.2. Analysis of the sales scheme and pricing plan of entrepreneurs

It is suggested, based on the above-mentioned, that entrepreneurs need to adjust the product price to ensure that the funding target is met. We start by investigating how entrepreneurs set a reasonable funding target that guarantees maximum capital. Compared to the case without financial constraints, we mainly investigate how entrepreneurs adjust the product pricing and sales scheme.

Proposition 5. Compared with the funding target$\overline{T}$, entrepreneurs should set an appropriate funding target T ($\overline{T} < T \le \widetilde{T}$) to ensure that the funding target can be met at the end of the CF campaign. It is discovered that the optimal funding target is$T^* = \widetilde{T}$.

From proposition 5, we find that entrepreneurs have a maximum financing threshold$\widetilde{T}$. Once the funding target exceeds this threshold, the CF campaign cannot succeed even if the product prices are adjusted. Therefore, a funding target within a reasonable range is crucial to the success of the campaign. To obtain maximum capital, we find that the optimal funding target should be equal to the maximum financing threshold, namely$T^* = \widetilde{T}$. The following proposition is employed to illustrate the entrepreneur's optimal sales scheme.

Proposition 6. With financial constraints, the two-stage sales scheme is most beneficial to entrepreneurs, while it is suboptimal for entrepreneurs to adopt a one-stage sales scheme because of $\pi^{co} \ge \pi_1^{co}$ strictly.

Proposition 6 explains the optimal sales scheme for entrepreneurs with financial constraints is a two-stage one. Unlike the case without financial constraints, entrepreneurs who adopt two different sales schemes should set the same CF price and obtain the same profit at the CF stage. In this case, entrepreneurs take the optimal CF price as the predominant factor to help reach the funding target first and then maximize profits by selling products in the retail market. Thus, we further investigate entrepreneurs' optimal pricing plan choices.

Proposition 7. With financial constraints, given$T^* = \widetilde{T}$, a thresholdα_0, where$\alpha_0 = 3\eta/(1+3\theta+3\eta-c)$, is derived. The optimal pricing plan is an increasing one when$\alpha < \alpha_0$. Otherwise, a decreasing price plan is better than an increasing one. Compared to the case without financial constraints, entrepreneurs are more likely to implement an increasing pricing plan because of $3\eta/(1+3\theta+3\eta-c) > 2\eta/(1+2\theta+2\eta-c)$ strictly.

Proposition 7 shows that financial constraints have some impact on the optimal pricing plan choice. With financial constraints, entrepreneurs deem the success rate of CF their top priority, followed by the task of marketing, and thus should decline the CF price to encourage more purchasing in CF campaigns. When the probability of product matching is high enough, entrepreneurs may try to increase the CF price to extract higher surplus from high-valued consumers. So, entrepreneurs are more likely to implement an increasing pricing plan to raise capital as much as possible in the CF campaign.

Proposition 8. Givenp_1^{co}*andp_2^{co}*, and$T^* = \widetilde{T}$, the maximum amount of capital the entrepreneurs can raise, $p_1^{co}*$ ($p_2^{co}*$), is increasing (decreasing) inαandθ; for any givenα, $p_1^{co}* < p_1^{two}*$and$p_2^{co}* < p_2^{two}*$.

Proposition 8 indicates that for a given optimal price and funding target, the change in both the probability of product matching and consumers' perceived value of extra rewards have reversed influence on the optimal CF price and retail price, which is similar to that described in Proposition 1. In comparison, entrepreneurs with financial constraints should set a relatively low CF price to attract more consumers to meet the funding target first, and then sell products at a discounted price to expand the product market. These results are driven by the "All-or-Nothing" mechanism because the funding target can only be met when enough consumers purchase the products.

5. Data analysis

After making the theoretical analysis, in this section, we crawl real data from the Kickstarter platform for verifying the theoretical results. Due to the fact that it is easy to uncover the development status of CF from the data of recent campaigns, we collect data from 502 successful technology CF campaigns most recently launched on Kickstarter. Moreover, in order to study whether differences exist in the funding targets between successful and failed campaigns, data on 502 latest failed campaigns are also collected. The obtained data consists of five items, including the funding target, reward description, the number of updates, the number of comments, and the follow-up sales link. Among them, the follow-up sales link enables us to quickly judge whether the entrepreneurs adopt a two-stage sales scheme. Then, we intend to deal with the following issues by analysing the data: (1) how the value of the funding target affects the choice of sales schemes, (2) which pricing plan should be adopted in a two-stage sales scheme, and (3) how to set a reasonable funding target.

First, in order to explore the relationship between the funding target and sales scheme selection, we collect both the data of 269 successful campaigns with the funding targets above $10,000 and the data of 233 successful campaigns with the funding targets of less than $10,000. Among the 269 campaigns, 191 campaigns (71%) adopted a two-stage sales scheme to continue selling products via online platforms after the funding targets were reached, whereas only 78 campaigns (29%) preferred a one-stage sales scheme as shown in Table 2. It can be seen that entrepreneurs prefer to implement a two-stage sales scheme from

Table 2
Statistical analysis of sales scheme selection.

The funding target	The choice of sales scheme		
	A one-stage sales scheme	A two-stage sales scheme	sum
>10,000	78	191	269
<10,000	122	111	233
Sum	200	302	502

Table 3
Statistical analysis of the pricing plan.

The funding target	The choice of pricing plan		
	An increasing pricing plan	A decreasing pricing plan	sum
>10,000	112	79	191
<10,000	50	61	111
Sum	162	140	302

this perspective. However, for campaigns with the funding targets of less than $10,000, we find that 111 entrepreneurs (48%) adopted a two-stage sales scheme, whereas 122 (52%) implemented a one-stage sales scheme. In this case, no significant difference can be seen in their choice of sales scheme. Hence, the statistical analysis demonstrates that entrepreneurs with financial constraints may prefer a two-stage sales scheme, while those without financial constraints have no particular preference.

Second, the reward descriptions of the 302 successful campaigns with a two-stage sales scheme are extracted to discuss the entrepreneur's pricing plan. In practice, entrepreneurs who adopt an increasing pricing plan usually announce both the discounted CF price and the retail price in the reward description and encourage consumers to purchase early by showing how much they can save. Thus, using the key word *save*, we find that 162 campaigns adopted an increasing pricing plan as shown in Table 3, of which 112 campaigns (69%) had the funding targets above $10,000 and 50 campaigns (31%) had the funding targets of less than $10,000. It can be inferred that entrepreneurs with financial constraints are more likely to adopt an increasing pricing plan to design a discounted CF price. A decreasing pricing plan was used by the remaining 140 campaigns. Since an increasing pricing plan announced by the entrepreneur would contribute to the success of the CF campaign, we treat the campaigns that are not labeled as an increasing pricing plan as those with a decreasing pricing plan in our study.

Finally, we attempt to examine how to set a reasonable funding target based on the two sets of data with 502 successful campaigns and 502 failed ones. From Fig. 2(b), we observe from the 502 successful campaigns that entrepreneurs tend to set a reasonable funding target, which is always less than $100,000. However, entrepreneurs with failed campaigns may set a higher funding target compared with those who succeeded, as shown in Fig. 2(a). In Fig. 2, the horizontal axis represents the number of successful and failed campaigns, and the vertical axis represents the funding target of each campaign.

From Table 4, it can be seen that 269 campaigns (54%) had the funding targets above $10,000 among the 502 successful campaigns. However, 466 (93%) campaigns had the funding targets above $10,000 for the failed campaigns. In addition, it is obvious that there are large differences in some indices between the two types of campaigns. Specifically, the maximum value, minimum value and average level of the funding targets of the failed campaigns are much higher than those of the successful campaigns. Also, the median of the funding targets of the failed campaigns is higher than that of the successful campaigns. From the above preliminary analysis, we think that it is probably that the funding target is a basic factor affecting the success of CF, and setting an inappropriate funding target may lead to the failure of the campaign. Moreover, according to the analysis of the number of updates and comments in Table 5, we find that the number of updates and comments of the successful campaigns far exceeded those of the failed campaigns. For successful campaigns, entrepreneurs are more willing to update campaigns and respond to comments to provide the pledged consumers with more extra experience in this progress. Thus, a reasonable funding target and extra experience would be essential to the acquisition of the funding target and profit maximization.

6. Conclusions

CF has emerged in recent years as a major financing channel for start-ups or individuals to replace traditional financing. The start-ups or individuals can raise capital from potential consumers to develop innovative products by launching CF campaigns. This paper mainly studies how entrepreneurs set optimal funding targets, product prices and sales strategies in a basic model. The impact of entrepreneurs' decisions on consumer surplus and social welfare is also explored. Moreover, we construct an analytical model to investigate whether entrepreneurs with financial constraints need adjustment in product pricing and sales schemes.

The main contributions of this paper are summarized as follows. Our study is the first to investigate the entrepreneur's sales schemes and pricing plans of CF products considering the characteristics of the reward-based CF. We find that these CF campaigns have unique features that are different from other sales activities, and prove that the entrepreneur should adopt the corresponding sales scheme and pricing plan under the different conditions. Second, we theoretically reveal the relationship between the funding target and the success of the CF campaign from the perspective of the sales schemes. We demonstrate that the funding target may affect the success of CF and the entrepreneur's optimal decision. Finally, we collect real data from the Kickstarter platform in order to verify the theoretical results by the analysis of the data. The results of the descriptive statistics show that the interaction between the entrepreneurs and consumers is also a factor that affects the success of CF.

The several main insights and implications can be summarized as follows. First, without financial constraints, entrepreneurs can choose between a two-stage sales scheme and a one-stage sales scheme. When the consumers' perceived value of extra rewards is high, a one-stage sales scheme is preferred in a medium range of the probability of product matching, but a two-stage sales scheme yields more benefits for entrepreneurs when the probability of product matching is low or high.

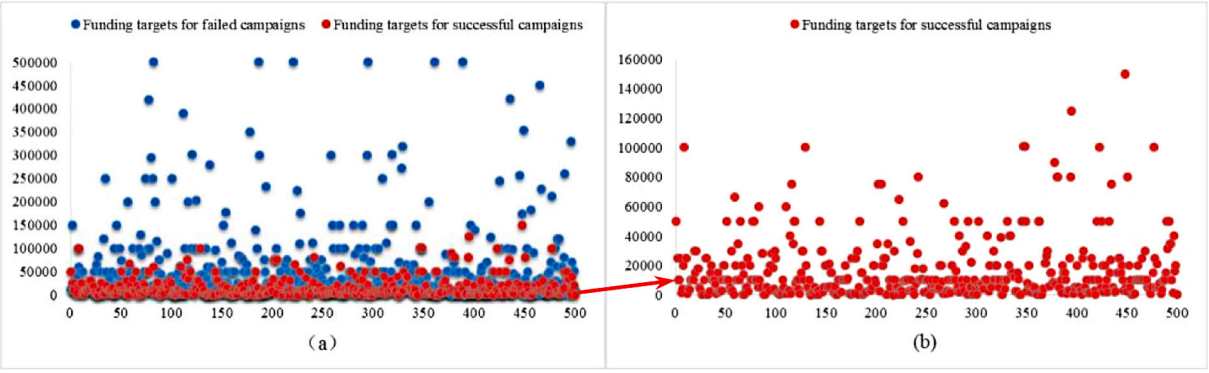

Fig. 2. The funding targets for the successful and failed campaigns.

Table 4
Statistical analysis of the funding target.

The results of campaigns	The funding target					
	The number of campaigns whose goals above 10,000	The number of campaigns whose goals under 10,000				
			Min	Max	Mean	Med
Success	269	233	1	150,000	15,725	10,000
Failure	466	36	400	2,500,000	92,392	30,000

Table 5
Statistical analysis of the number of updates and comments.

The results of campaigns	The number of updates				The number of comments			
	Min	Max	Mean	Med	Min	Max	Mean	Med
Success	0	88	10.67	9	0	5964	223.86	57
Failure	0	25	0.77	0	0	41	1.096	0

When the consumers' perceived value of extra rewards is low, a two-stage sales scheme is absolutely superior to a one-stage one. This analysis provides a possible explanation of why entrepreneurs who launch innovative campaigns on Kickstarter usually sell products in two stages–the CF stage and the retail stage.

Second, when the probability of product matching is low, it is optimal for entrepreneurs to adopt an increasing price plan; otherwise, they are more willing to carry out a decreasing price plan. Compared with those without financial constraints, entrepreneurs with financial constraints are more likely to adopt an increasing price plan because they have to offer a discounted price to encourage early purchase. Contrary to most actual cases, entrepreneurs should set a higher CF price first, followed by a lower retail price when the probability of product matching is high.

Third, to ensure the success of the campaign, entrepreneurs with financial constraints should set an appropriate funding target, with the optimal funding target equal to the maximum financing threshold. This means that once exceeding the threshold, the funding target cannot be met even with adjusted product prices. Moreover, such an appropriate funding target is beneficial not only to the pledged consumers but also to the entrepreneur. It is worth mentioning that the entrepreneurs should set funding targets modestly.

Finally, it is found that a higher probability of product matching may enhance social welfare but dampen consumer surplus under certain conditions. The intuitive observation is that a higher probability of product matching is beneficial to the profit and long-term development of entrepreneurs. Therefore, more detailed product information should be provided at the CF stage to deepen consumers' understanding of the product and boost their confidence in it.

This study provides some management implications for entrepreneurs' marketing decisions; however, there are still a few limitations. First, we focus on monopolistic entrepreneurs and ignore the competition between them, which may occur in practice due to imitation behaviour. Second, we study the CF platforms with "All-or-Nothing" mechanism, such as Kickstarter; however, some CF platforms adopt a "Keep-it-All" mechanism, which may lead entrepreneurs to different marketing decisions. Third, we assume that consumers are myopic, and the forward-looking behaviour of consumers can be examined by investigating the effect of consumers' current decisions on subsequent consumers' decisions in future research.

Credit author statement

Yao Zhang: Conceptualization, Methodology, Formal analysis, Supervision, Validation, Writing - original draft, Writing – review & editing, Funding acquisition. **Ying Tian:** Methodology, Formal analysis, Writing - original draft, Writing – review & editing.

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Please note that all authors have contributed equally to this article.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (71871050);and the Liao Ning Revitalization Talents Program (XLYC1805012).

Appendix A. Appendix

Proof for proposition 1: Without financial constraints, the expected profit of the entrepreneur can be expressed as $\pi_{two} = (p_1^{two} - c)d_1^{two} + (p_2^{two} - c)d_2^{two}$ in a two-stage sales scheme. First, the first-order and second-order partial derivatives of the profit function with respect to the CF price and the retail price are derived. Then, a Hessian matrix is formulated as $H = \begin{vmatrix} \partial^2\pi_{two}/\partial p_1^{two2} & \partial^2\pi_{two}/\partial p_1^{two}\partial p_2^{two} \\ \partial^2\pi_{two}/\partial p_2^{two}\partial p_1^{two} & \partial^2\pi_{two}/\partial p_2^{two2} \end{vmatrix} = 3 > 0$ and a unique optimal solution, where p_1^{two*}, p_2^{two*} and π_{two}^*, is obtained. In a one-stage sales scheme, we use the same method to obtain the optimal p_1^{one*} and π_{one}^*. From the formula above, we can easily find the influence of α and θ on p_1^{two*}, p_2^{two*}, π_{two}^*, p_1^{one*} and π_{one}^*.

Proof for proposition 2: Given p_1^{two*} and p_2^{two*}, the difference between the CF price and the retail price is $\Delta p = p_1^{two*} - p_2^{two*}$. If $\alpha < 2\eta/(1 + 2\theta + 2\eta - c)$, we derive $\Delta p < 0$; otherwise, $\Delta p \geq 0$ is constant.

Proof for proposition 3: We defined that the profit difference between the two sales schemes is $\Delta\pi = \pi_{two}^* - \pi_{one}^*$; and, according to the discriminant and square root formula, we derive $\theta_{1,2} = \left((7(1-\alpha)\eta/\alpha + 5c - 5) \pm 2\sqrt{14((1-\alpha)\eta/\alpha)^2 - 6(1-c)^2}\right)\Big/7$. Especially, $\Delta\pi \geq 0$ is constant when $\Delta < 0$, so $\pi_{two}^* \geq \pi_{one}^*$ absolutely when $\alpha \geq \eta/\left(\sqrt{3/7}(1+c) + \eta\right)$. When $\alpha < \eta/\left(\sqrt{3/7}(1+c) + \eta\right)$, we take further analyses and find $\pi_{two}^* < \pi_{one}^*$ when $\theta_1 < \theta \leq \min(\theta_1, 1)$, and $\pi_{two}^* \geq \pi_{one}^*$ when $\theta \leq \theta_1$.

Proof for propositions 7: Given$T^* = \widetilde{T}$, the difference between the CF price and the retail price is$\Delta_p^{co} = p_2^{co*} - p_1^{co*}$, where$2\Delta_p^{co} = (1-\alpha)\eta/\alpha - \theta + c - p_1^{co*}$. We derive $\Delta_p^{co} < 0$when$\alpha < \alpha_0$, where$\alpha_0 = 3\eta/(1 + 3\theta + 3\eta - c)$; otherwise, we get$\Delta_p^{co} > 0$. In comparison, entrepreneurs with financial constraints are more willing adopt an increasing price plan because$\alpha_0 > 2\eta/(1 + 2\theta + 2\eta - c)$ is constant.

Proof for proposition 8: With financial constraints, we find that$T^* = \widetilde{T}$and derivep_1^{co*}andp_2^{co*}, respectively. Then, compared to the case without financial constraints, we have that$p_1^{two*} - p_1^{co*} = (1 - c + (1-\alpha)\eta/\alpha - \theta)/6andp_2^{two*} - p_2^{co*} = (1 - c + (1-\alpha)\eta/\alpha + \theta)/12$. So, $p_1^{two*} \geq p_1^{co*}andp_2{}^{two*} \geq p_2^{co*}$, because$(1-\alpha)\eta/\alpha + p_1^{co*} - \theta - p_2^{co*} > 0$is constant.

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