Planning crowdfunding campaign launch date under uncertainty

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Abstract

This paper proposes a decision-making framework for entrepreneurs who are willing to launch their crowdfunding campaign on a crowdfunding platform. In particular, we propose a method, based on real options, for choosing the launch date of the campaign depending on the observed status of the platform. The entrepreneur's objective is to maximize the expected amount of funds she collects on the platform, and this latter depends on the quality of the proposed project, but also on the number and qualities of the concurrent projects during the campaign lifetime. We model the platform state evolution with time using a Markov chain and derive the expected campaign outcome starting from a given status. We then propose a dynamic programming approach that determines the optimal campaign launch time.

1 Introduction

Crowdfunding is becoming increasingly important for entrepreneurs who are willing to bypass classical funding channels such as venture capital and credit loans. These entrepreneurs are able to address directly the crowd via Internet-based Crowdfunding Platforms (CFP) for collecting financial resources either in the form of donation or in exchange for the future product or some form of reward. Even if crowdfunding started as a niche, it gained increasingly in importance in the past ten years.

Some of the crowdfunding literature focused on identifying the parameters that lead to the success of the campaign. For instance, when it comes to the duration of the campaign, [1] showed, based on an empirical analysis, that a longer duration of the campaign reduces the probability of success, while [2] observes a positive correlation between duration and success. [3] investigated theoretically

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this issue and found out that there is an optimal duration that maximizes the success chance. Other studies focused on the platform behaviour and its impact on the campaign success. For instance, [4] proposed a project promotion strategy where the platform highlights dynamically a subset of projects so that the overall success rate is increases.

In this paper, we consider the crowdfunding campaign design from an entrepreneur perspective and address the issue of campaign launch date. Launch date has been studied as a key success factor when launching a commercial product, like for instance in the mobile apps market studied in [5]. However, the launch date dimension has not been yet investigated in crowdfunding, even of [6] identified the amount of competition at launch date as an influencing parameter on success. This paper fills this gap by studying the optimal launch date. We develop an optimization framework where the entrepreneur plans the crowdfunding campaign launch date so that its expected outcome is maximized. We also develop a dynamic policy, based on real options, where the entrepreneur observes that status of the platform and decides whether to launch the campaign or wait for future developments.

The remainder of this paper is organized as follows. Section 2 develops a model for the platform state evolution and proposes an optimization framework for the launch time. Two flavors are proposed, with an initial planning algorithm and a dynamic programming one. Section 3 implements the proposed algorithms and studies the impacts of the different platform parameters on the optimal launching time. Section 4 concludes the paper.

2 Optimal campaign launch

2.1 System model

We consider a crowdfunding platform that proposes a set of projects. We focus on a set of projects that can be regarded as competitors, i.e. that attract funders with common interest, e.g. technology, arts, etc. A platform may propose different types of projects but we focus here on projects belonging to the same domain. We model the system from the point of view of an entrepreneur whose campaign is ready to be launched at time 0 and whose duration is predetermined to d days. However, she can delay the launch to a subsequent date, if this delay may increases her chances of success.

Let α_0 be the number of projects that are active at time 0 and let β_i be the closing date of project $i \in [1, \alpha_0]$. Among these projects, the number of remaining active projects at time $t > 0$ is given by:

$$\alpha_t = \alpha_0 - \sum_{i=1}^{\alpha_0} I_{\beta_i < t} \tag{1}$$

where I_C is the indicator function equal to 1 if condition C is satisfied, and to 0 otherwise.

At time $t > 0$, new projects may arrive that will last for a certain time. We model that arrival rate of new projects as a Poisson process of intensity λ (new projects per day). For future arrivals, the campaign durations are not yet known but are equal in average to D days. We model the campaign duration by a geometric random variable of parameter $1/D$, meaning that at each time interval, the campaign expires withe probability $1/D$ ans stays active for at least the next day with probability $(1 - 1/D)$[1].

Let X_t be the number of active projects at time t that arrived at dates $t' \in [1, t]$ and that did not yet expire (X_t does not include the α_t projects of equation (1)). X_t evolves following a Markov chain. When $X_t = n$ active projects, the number of projects leaving the platform can be modeled as a binomial random variable of parameters $(n, \frac{1}{D})$ and the probability of k projects leaving is thus computed by:

$$q_{k,n} = \binom{k}{n} \frac{(D-1)^{n-k}}{D^n} \tag{2}$$

where $\binom{k}{n} = \frac{n!}{k!(n-k)!}$. As the arrivals of new projects are modeled as a Poisson distribution, the probability of having l new arrivals in an interval is calculated by:

$$a_l = \frac{\lambda^l}{l!} e^{-\lambda} \tag{3}$$

We can compute the following transitions $P_{n,m}$ from state $n \in \mathcal{N}$ to state $m \in \mathcal{N}$, where $\mathcal{N}$ is the set of natural positive integers:

$$P_{n,n+k} = \sum_{l=0}^{n} a_{l+k} q_{l,n}, \forall k \geq 0 \tag{4}$$

and

$$P_{n,n-k} = \sum_{l=0}^{n-k} a_l q_{l+k,n}, \forall k \in (0, n] \tag{5}$$

Note that equation (4) (resp. equation (5)) accounts for all the possible combinations of campaign initiation and expiration that lead to an increase (resp. decrease) of the number of active projects by $k \geq 0$ (resp. $k \leq n$). These transition probabilities are arranged within the transition matrix $\mathbf{P}$.

Let Z_t be the total amount of money collected on the platform at time t. The target project expects to collect $\frac{Z_t}{X_t + \alpha_t + 1}$ if it is active a time t, supposing an even distribution of funds among all active projects.

2.2 Initial planning of the launch time

The objective of the entrepreneur is to start its campaign at time τ and end it at time $\tau + d$, so that the expected amount of collected funds $f(\tau)$ is maximized.

[1] It is easy to verify that the average duration of such a variable is equal to D.

The simplest option for the entrepreneur is to fix, upon the readiness of the campaign, the future launch date on the platform. Supposing that the campaign cannot be delayed beyond a date T, this can be formalized by the following optimization problem:

$$\max_{\tau \in [1,T]} L(\tau) \tag{6}$$

with

$$\begin{aligned} L(\tau) &= E[\sum_{t=\tau}^{\tau+d} \frac{Z_t}{X_t + \alpha_t + 1} \mid X_0 = 0] \\ &= E[Z] \sum_{t=\tau}^{\tau+d} E[\frac{1}{X_t + \alpha_t + 1} \mid X_0 = 0] \\ &= \sum_{t=\tau}^{\tau+d} \sum_{m \geq 0} (\mathbf{P}^t)_{0,m} \frac{E[Z]}{m + \alpha_t + 1} \end{aligned} \tag{7}$$

where $\mathbf{P}^t$ is the transition matrix that describes the system state evolution after t days (that is obtained by multiplying $\mathbf{P}$ by itself t times). The denominator of each term in the sum is the number of active projects at t, that is composed of the "old" projects that are still active (α_t), the projects that started at positive times, and the project of interest.

The entrepreneur selects the launch date τ^* that maximizes the outcome in equation (6) and requests it from the platform.

2.3 Dynamic planning

We now turn to the more dynamic case where the entrepreneur observes the evolution of the state of the platform and decides to launch or delay its campaign based on the new observations. However, once the campaign is launched, the decision is irreversible. We model this policy by a real option.

If the platform is in state n at time τ and the entrepreneur decides to launch its campaign immediately, the expected pledges will be:

$$\begin{aligned} L(\tau, n) &= E[\sum_{t=\tau}^{\tau+d} \frac{Z_t}{X_t + \alpha_t + 1} \mid X_t = n] \\ &= \sum_{t=\tau}^{\tau+d} \sum_{m \geq 0} (\mathbf{P}^{t-\tau})_{n,m} \frac{E[Z]}{m + \alpha_t + 1} \end{aligned} \tag{8}$$

If, however, the decision is to delay the campaign launch, the entrepreneur will get the outcome of the future decision at the next time epoch.

2.3.1 Dynamic programming algorithm

We solve this problem using dynamic programming. Let $O(T,n) = L(T,n)$ be the option value at time T if the platform is in state n. In fact, at time T, the entrepreneur has to launch its campaign and hope for the best, independent of the platform state.

At a time $\tau < T$, the agency has also two alternative choices: launch now and get $L(\tau,n)$ or wait one period and then decide. The value of the option is thus:

$$O(\tau,n) = \max[L(\tau,n), W(\tau,n)] \tag{9}$$

where $W(\tau,n)$ is the waiting value computed depending on the transition probabilities of the platform:

$$W(\tau,n) = \sum_{m\geq 0} P_{n,m} O(\tau+1,m) \tag{10}$$

We can write the following algorithm:

- Start at the maturity date T beyond which the campaign launch cannot be delayed.
- at $\tau = T$ the option is calculated as $O(T,n) = L(T,n)$ for all $n \geq 0$.
- move back one period to $\tau = T-1$ and calculate $O(T-1,n)$ as in equation (9)
- move back one period and compute $O(T-2,n)$, and so on until calculating O_0.
- For a given time τ, let S_τ be the maximal number of projects X_τ so that the value of immediate launch is larger than the value of waiting.

2.3.2 Expected launch time

While the optimization problem is resolved by moving backwards in the state space tree, the expected campaign launch date is computed by moving forward in the tree. Let p_τ be the probability of launching the campaign exactly at time τ. At time 0, the decision depends on the waiting and launch values:

$$p_0 = I_{L(0,0)\geq W(0,0)} \tag{11}$$

At any time $\tau > 0$, the project is launched if $X_\tau \leq S_\tau$ and the launch did not occur before:

$$\begin{aligned} p_\tau &= Pr[X_\tau \leq S_\tau](1 - \sum_{t=0}^{\tau-1} p_t) \\ &= \sum_{m=0}^{S_\tau} (\mathbf{P}^\tau)_{0,m}(1 - \sum_{t=0}^{\tau-1} p_t) \end{aligned} \tag{12}$$

The expected launch time is thus computed by:

$$\bar{\tau} = \sum_{\tau=0}^{T} \tau p_\tau \qquad (13)$$

3 Numerical experiments

We consider in our numerical applications a platform whose parameters are given in Table 3. Before evaluating the launch date optimization algorithms of sections 2.2 and 2.3, we illustrate in Figure 1 a realisation of the platform evolution for the example of table 3; the projects initially active expire with time, while new projects are initiated, leading to a fluctuation of the number of active projects.

Table 1: System parameters.

General parameters	
Average campaign size on the platform	10 days
Max. waiting time before launch	50 days
Number of initial projects α_0	variable ([0,15])
Initiation rate of projects	variable ([0.1,0.8] project/day)
Parameters of the specific setting	
Number of initial projects α_0	8
Expiration dates of ongoing campaigns	[3 5 6 7 12 13 15 16]
Initiation rate of projects	0.4 project/day)

3.1 Offline optimization

We start by the initial optimization algorithm where the project owner plans the initial launch date with the platform manager once its campaign is ready to go.

We first consider a realization of the system, with 8 projects as in the example of table 3. We plot in Figure 2 the value of launching the campaign at different times $t \geq 0$, computed as the amount of money collected starting from τ and for the campaign duration. We have normalized the average daily inflows ($E[Z]$) to 1. The launching value starts increasing, reaches its maximum for $\tau = 17$, and then decreases. This timing maximizes the value of the campaign as in equation (6).

In order to understand the long term behaviour of the system, we perform Monte-Carlo simulations where, for a fixed number of active projects α_0, we simulate a large combination of the realizations of the expiry dates for each of the projects. We plot in Figure 3 the expected launch time of the campaign when the number of initial projects α_0 increases. We observe that the entrepreneur

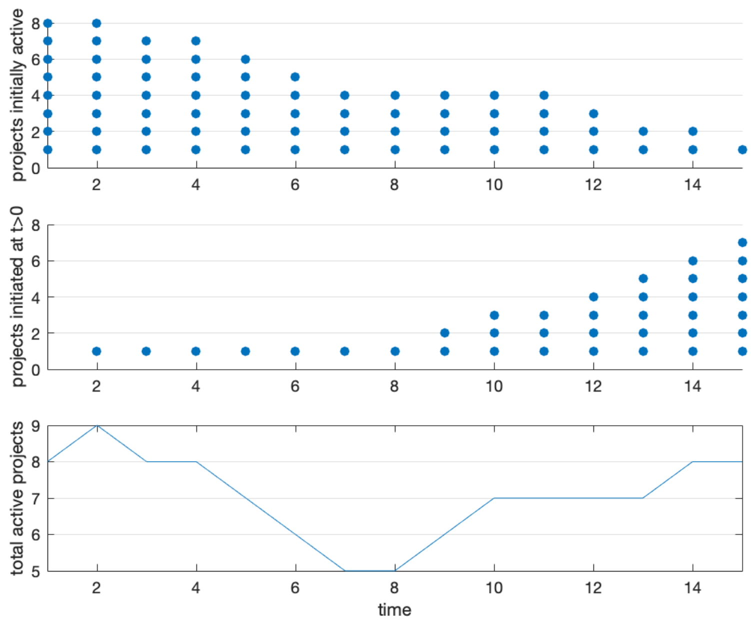

Figure 1: Illustration of the evolution of the platform for the example in table 3.

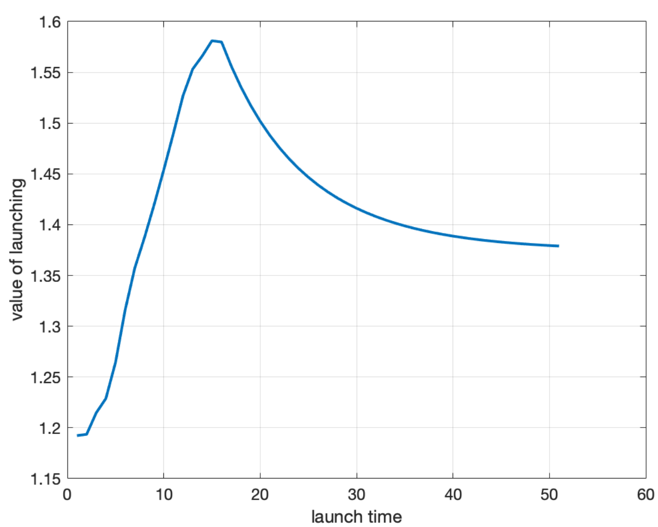

Figure 2: Value of launching the campaign at different times.

has to wait for a longer time when the platform is more crowded. We illustrate two cases with different platform project arrival rates ($\lambda = 0.2$ and $\lambda = 0.7$ projects per day) and observe that, in a platform with a larger arrival rate of projects, the waiting time is generally low, unless the number of ongoing projects is excessively high.

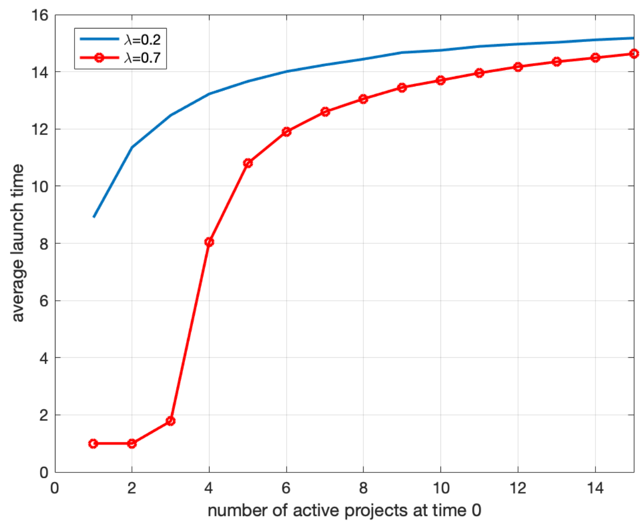

Figure 3: Average launch date for different numbers of initial projects

Figure 4 varies the initiation rate of projects and shows that the average launch time decreases with an increasing λ. The launch time remains however far, even for a large project initiation rate, when the number of active projects at time 0 is large.

3.2 Dynamic algorithm

We now consider the dynamic setting where the entrepreneur observes the system evolution and adapts its decision with time. We first consider the illustrative example of Table 3 and apply the algorithm of section 2.3.1 to compute the values of launching (equation (8)) and waiting (equation (10)) for different states X_t. Figure 5 compares the values of waiting and launching for two λ's. When waiting is better than immediate launching for a particular state X_t, Figure 5 gives it the value 0, and the value 1 otherwise. We can observe that launching becomes interesting for large t and small X_t. When λ is large, campaign has to be launched earlier than for a smaller λ and even when X_t is relatively large.

Figure 6 plots the expected launching time of equation 13. This expected time decreases slowly and then abruptly. We can observe a threshold effect on λ beyond which it becomes optimal to launch immediately the project.

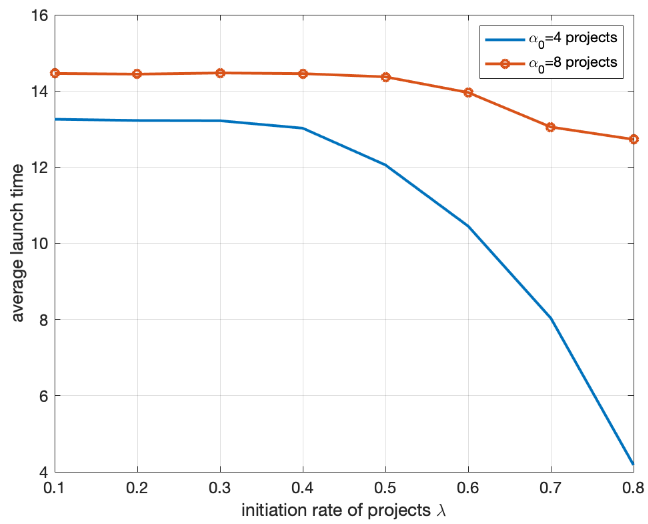

Figure 4: Average launch date for different campaign initiation rates.

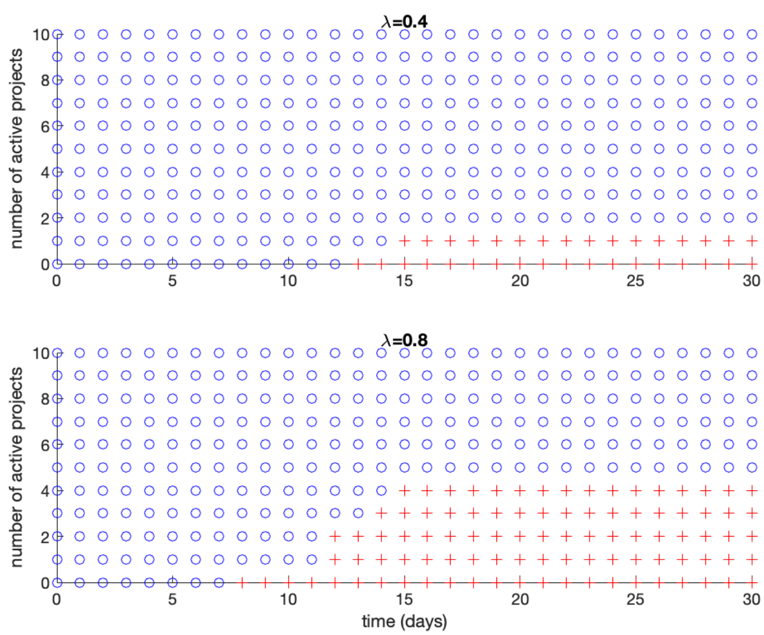

Figure 5: Decision tree for two examples of the project initiation rate. The red crosses represent the states where the value of launching is larger than the waiting value. Blue circles are drawn otherwise.

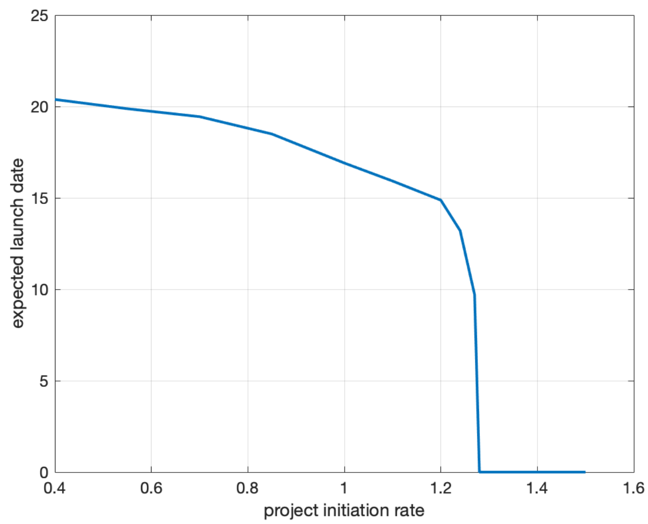

Figure 6: Expected waiting time before launching.

In order to understand this threshold behaviour, we compute, for each α_0 the corresponding threshold on λ beyond which it becomes optimal to launch immediately (at $t = 0$). For each α_0, we consider a large number of combinations on the campaign expiration dates, and apply the dynamic programming algorithm for increasing values of λ, until the value of launching at $t = 0$ exceeds the value of waiting. We plot in Figure 7 the obtained thresholds. They are increasing with α_0, meaning that, if the number of ongoing projects is large, we can afford to wait for a larger intensity of project initiation.

4 Conclusion

In this paper, we have proposed a framework for optimizing the launch timing of crowdfunding campaigns from the entrepreneur's point of view. We first developed a model for the platform dynamics and computed the expected amount of collected funds for different launch times, depending on the platform status and parameters. We then used this model for formulating an optimization problem and solved it with two flavors: an initial planning that optimizes, at time 0, the future launch date, and a dynamic scheme based on real options where the entrepreneur adapts dynamically the launch date based on her observations.

As of future work, we aim at extending the model from the monopolistic crowdfunding market studied in this paper to a competitive market where the entrepreneurs have the choice between different platforms for launching their campaigns.

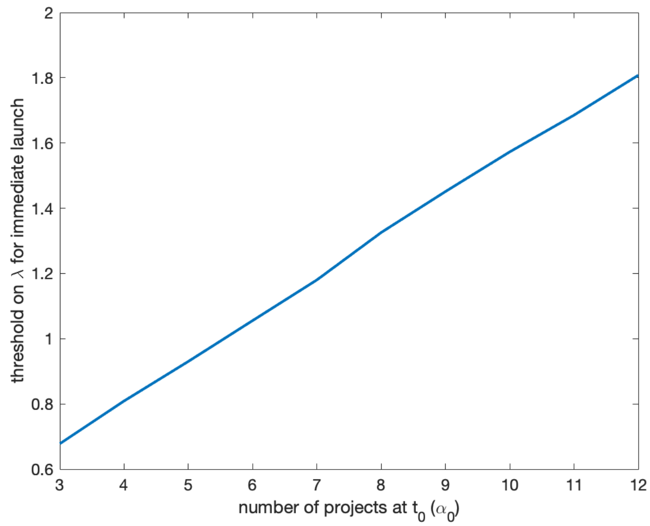

Figure 7: Threshold on the initiation rate λ beyond which immediate launch is optimal.

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