A Dynamic Model of Crowdfunding

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1 Problem Description

Crowdfunding is quickly emerging as an alternative to traditional methods of funding new products. In a crowdfunding environment, a producer (also referred to as seller) solicits financial contributions from the crowd, mostly in the form of pre-buying a still-unrealized product.[1] These funds are then used to cover production costs. Usually, the producer sets a threshold for the amount of funds required to start production, and the project is not funded if the campaign is unable to raise that amount within a pre-specified period of time. Crowdfunding platforms like Kickstarter and Indiegogo regulate these campaigns by a) vetting the seller and the proposed project, and b) ensuring that anyone who makes a pledge to buy actually follows through with their purchase if the campaign is successful. This new funding paradigm has the potential to rectify many of the common inefficiencies found in the traditional demand and production process, especially for niche or new products that carry with them a high degree of uncertainty. A seller does not commit to production until demand is observed and the necessary capital is raised, and consumers who are interested in products that are deemed too risky or too specialized to produce get a chance to help bring these products to market.

There are plenty of interesting problems that come up in organizing a crowdfunding campaign. Some papers have considered the problem in a static setting, where consumers *simultaneously* decide whether to pledge or not,[2] while others consider how a seller should design a menu of products

[1] One successful example of crowdfunding is the Pebble watch, a watch that uses e-paper and can be connected via bluetooth to control various appliances and/or phones. Pebble started a crowdfunding campaign with the goal of raising $100,000 to start production. It ended up raising more than $10,000,000 in under two months from consumers who liked the idea enough to support it.

[2] Belleflamme, Paul, Thomas Lambert, and Armin Schwienbacher. "Crowdfunding: Tapping the right crowd." Journal of Business Venturing (2014)

for this environment.[3] In this paper, we focus on one of the more important aspects, mainly, the collective action (and learning) problem that consumers face in a dynamic setting. Obviously, the longer the duration of a campaign, the higher the chances that consumers get to hear about it through word-of-mouth and/or advertising, and thus the larger the pool of potential contributors. On the other hand, since a contribution is effectively a contract to purchase the product in case of campaign success, a consumer's contribution ties up funds until the campaign is over.[4] Because of this, there is an incentive to free ride: consumers can observe the progress of the campaign –which is made public– and decide to contribute only after the campaign has already reached its goal. Of course, this exact behavior is what can hinder the campaign from reaching its goal in the first place. This paper examines how a producer should set the price and duration of the campaign in order to address this problem.

2 Model and Results

We consider a producer who is pre-selling a product through a crowdfunding campaign. The producer is interested in raising capital C to cover his production costs (for example, buying equipment or hiring labor) as well as make a profit.[5] He does this by setting a price p for the product and duration T for the campaign. The campaign's funding goal, C, is public knowledge. Consumers arrive over time and have prior beliefs about what the quality of the product will be, and consequently about the value that they will get out of it. They update these beliefs over time as a function of the (publicly known) current total contribution, with the assumption that this quantity aggregates some of the dispersed priors about the quality of the product. This implies that the higher the amount pledged at time t, the higher the beliefs of consumers (who still have not pledged) about the potential quality of the product and the chances of success. We assume the seller and the consumers know the initial distribution of beliefs as well as the update rule (which we take to be Bayesian). A

[3] Hu, Ming, Xi Li, and Mengze Shi. "Product and Pricing Decisions in Crowdfunding.", Forthcoming in Marketing Science.

[4] Even though a consumer does not pay the product's price until the campaign is successful, by making a contract to buy he forfeits some of the options he has in spending that money. For example, a consumer may pledge to buy Product A, and after he makes that pledge, finds another Product B that he prefers but cannot buy because he has committed to buying Product A and buying both products would be too costly and/or impractical.

[5] We first consider the case when C is exogenous and later examine how to optimally select it.

producer discounts the campaign duration (so that all else being equal, he prefers shorter to longer campaigns), while consumers have inverse-discounting of money (so that they prefer spending the same amount of money further into the future instead of spending it today). If at the end of the campaign the cumulative pledging of consumers meets or exceeds the funding goal, then all consumers who made a pledge pay p each, otherwise no funds are exchanged.

Our first result is a sharp characterization of a pattern that is observed in the data on crowdfunding campaigns. Namely, the bimodal distribution of campaign outcomes. Campaigns either succeed, or fail to generate more than 20% of their funding goal, i.e. it is quite unlikely that a campaign fails and in the process raises any significant portion of its target funding. The possible outcomes of any campaign are overwhelmingly tilted towards either success or dismal failure.[6] We show that this distinct pattern arises from a phase transition in the dynamic process described above, where at some point in time backers either estimate the probability of success to be fairly low and abandon the project, or conversely estimate that the campaign will succeed and go forward with making a pledge.

Our second set of results is derived from analyzing a dynamic programming formulation. We delineate how the parameters of the problem interact with each other and prescribe how to optimally set the price p and duration T as a function of consumer valuations, the learning dynamics, and the discount factor so as to maximize the expected outcome of the campaign. Importantly, in characterizing the dynamics of the process and the behavior of consumers, we introduce and analyze a novel technique that we call an *anticipating* random walk. This new analytical tool was developed to address one feature that separates the crowdfunding model from other models in consumer learning. The majority of the literature on consumer and social learning considers an agent who takes an action after observing past outcomes by other agents. In contrast, consumers in our setting make decisions not just based on observing past actions or outcomes, but also by evaluating the impact of their actions on the future decisions of other agents, and how this effect ultimately comes back to benefit them. We believe that this method will find application beyond the crowdfunding environment, particularly in domains where agents are required to dynamically solve a collective action problem and where outcomes are determined through an aggregation of agents' decisions.

[6] As of December 2014, 49% of projects on Kickstarter failed to generate more than 20% funding, while 40% were successfully funded.