# Information Design in Crowdfunding under Thresholding Policies

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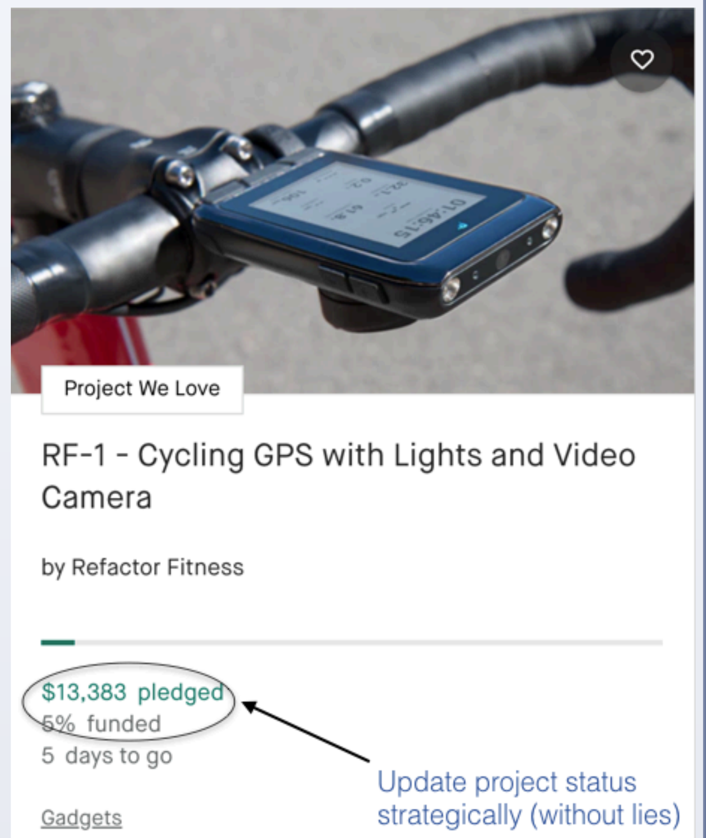
## INTRODUCTION

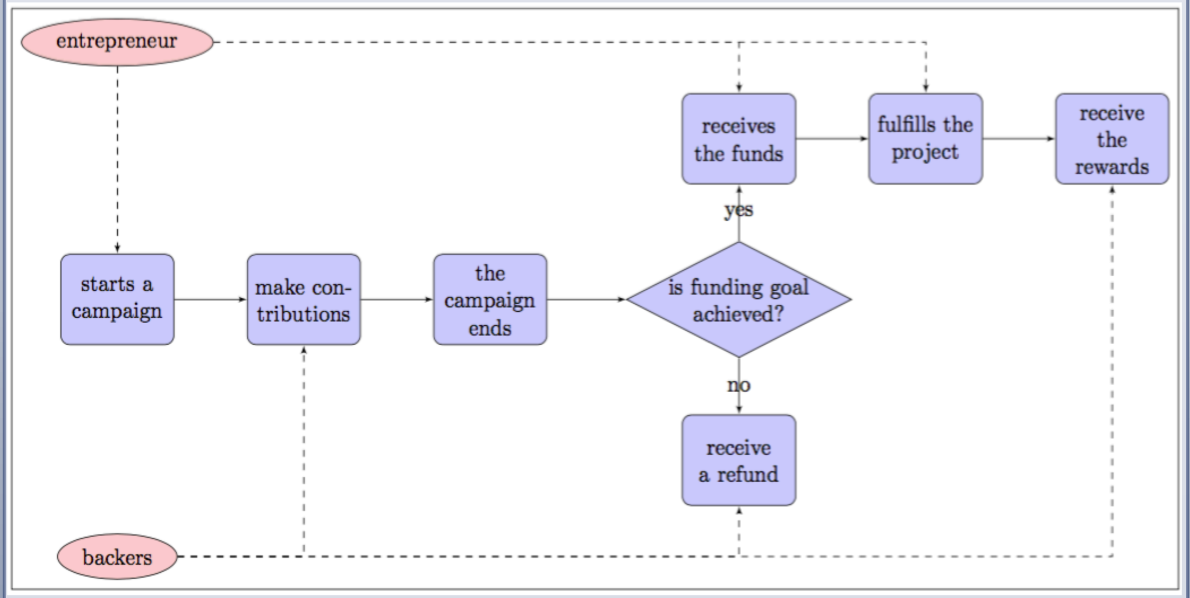
Crowdfunding has emerged as a prominent way for entrepreneurs to secure funding without sophisticated intermediation. In crowdfunding, an entrepreneur often has to decide how to disclose the campaign status in order to collect as many contributions as possible. Such decisions are difficult to make primarily due to incomplete information. In this paper, we propose information design as a tool to help the entrepreneur to improve revenue by influencing backers' beliefs.




Our work advance the-state-of-the-art in the following ways:

- We show that excessive information disclosure weakly shrinks the entrepreneur's revenue when backers use cutoff policies.
- We demonstrate that the widely-adopted immediate-disclosure policy is not optimal.
- We introduce a heuristic algorithm called Dynamic Shrinkage with Heuristic Selection (DSHS) to help the entrepreneur make decisions on information-disclosure policies.
- Our simulation results show that entrepreneurs can benefit from dynamic information design with appropriate heuristics.

## DECISION MAKING IN CROWDFUNDING




### Backers' Decision Models

- Make decisions based on estimates of the project's probability of success.
- The beliefs are correlated with the entrepreneur's updates of the project status.
- Use thresholding policies to decide whether to contribute or not.

### The Entrepreneur's Objective

- Implement information-disclosure policy to attract as many contributions as possible within the deadline so that the project will get funded.

### Design Constraints

- The design of disclosure policies should not be based on backers' later decisions, and should not use later project status information (No Clairvoyance).
- Backers' estimate processes, thresholds, and expected utility for making a contribution are all private to themselves.

## OPTIMAL INFORMATION DESIGN

### Key Concepts

- Information design: the approach of devising information structures that determine which pieces of information are disclosed to whom for desirable outcomes.
- Blackwell's theorem: Let $\xi_1$ and $\xi_2$ represent two pieces of information, the following conditions are equivalent::
  - When the agent chooses $\xi_1$, her expected utility is always at least as big as the expected utility when she chooses $\xi_2$, independent of the utility function and the distribution of the input.
  - $\xi_2$ is a garbling of $\xi_1$.
- Types of information:
  - Vertical Information – if one piece of information is always preferred whatever the information receivers' types are
  - Horizontal information – If two pieces of information are not comparable without prior knowledge about the information receivers' types.
- Order of project status report:
  - Proposition 1 - An earlier report of project status is always weakly preferred if the project status of the two reports are the same.
  - Proposition 2 - A later report of project status is always weakly preferred if the revenue increases by more than one contribution each time between the period of the two statuses.

### Excessive Disclosure Shrinks Revenue

We prove that excessive information disclosure weakly diminishes the chance that a backer will contribute.

- Lemma 1 - If the order of two project status reports can be identified, the low-order report does not increase the chance of backers' contribution.
- Lemma 2 - If the partial order of the two project status reports cannot be identified, excessive information disclosure weakly decrease backers' projections of the project's probability of success.

### Immediate Disclosure is not Always Optimal

- Immediate disclosure: An immediate-disclosure policy always reveals the current project status to all the backers in the campaign.
- Immediate-disclosure policy is widely adopted by entrepreneurs on major crowdfunding platforms due to its ease of implementation.
- Immediate-disclosure policy is not always optimal in crowdfunding:
  - Lemma 3 – Before the campaign reaches the fundraising goal, immediate disclosure is optimal if and only if the project state increases monotonically in time by at least one contribution each time.
  - Lemma 4 – After the campaign reaches the fundraising goal, immediate disclosure is optimal.

### Optimal Information Design is not Implementable

- Optimal information design needs a prior knowledge of the sequence of backers' decisions in advance.
- This requirement violates the *No Clairvoyance* constraint.

## DYNAMIC INFORMATION DESIGN

### Dynamic Shrinkage with Heuristic Selection

We introduce a heuristic algorithm called *Dynamic Shrinkage with Heuristic Selection (DSHS)* to help the entrepreneur make decisions on information disclosure. DSHS treats two conditions separately:

- Before the campaign reaches the fundraising goal, DSHS determines the disclosure policy according to two processes: dynamic shrinkage and heuristic selection.
- After the campaign reaches the fundraising goal, DSHS discloses information immediately.

**Algorithm 1** *DSHS*

**Input:** $t$ - time; $s(t)$ - project status at time $t$; $\mathcal{I}(t)$- backers in the campaign.
**Output:** $(d(i,t))_{i\in\mathcal{I}(t)}$- the entrepreneur's decisions on information disclosure for backers in the campaign at time $t$.

```
if t ≤ T then
    for each backer i ∈ I(t) do
        if current revenue M(t) < G then          ▷ before success
            Include all the available project status into H_i(t)
            Sort H_i(t) in the ascending order of |s(k)|
            Remove the least promising candidates in H_i(t)
            Select the project status s(k_sel) using heuristics
            Finalize disclosure decision d(i,t) ← (s(k_sel), t)
        else                                       ▷ after success
            Disclosure current status, i.e., d(i,t) ← (s(t), t)
        end if
        Update revenue M(t+1) = M(t) + α_i(t) · P
        Update project status s(t+1) = M(t+1)/G
    end for
end if
```

### Dynamic Shrinkage

- Rank all the available choices
- Remove the least promising choices which are less preferred by the backers according to the order of project status report (Propositions 1 & 2)
- This process eliminates excessive information disclosure that weakly shrinks revenue.

**Algorithm 2** *SHRINK*

**Input:** $H$- sorted project status disclosures
**Output:** $H'$-remaining status disclosures after shrinkage

```
if |H| ≥ 2 then
    while s(k_1), s(k_2) ∈ H, k_1 < k_2 do
        if |s(k_1)| = |s(k_2)| then
            H ← H \ {s(k_2)}                        ▷ By Proposition 1
        end if
        if |s(k_2)| − |s(k_1)| ≥ (k_2 − k_1) · P/G then
            H ← H \ {s(k_1)}                        ▷ By Proposition 2
        end if
    end while
end if
H′ ← H
```

### Heuristic Selection

Ithere are still at least two choices available, then the remaining set of choices is horizontal. The entrepreneur can use simple heuristics (e.g., random, greedy, ∈ - greedy, and softma) to make the final decisions. We further introduce a meta algorithm.

**Algorithm 3** *META*

**Input:** $H'$-remaining status disclosures after shrinkage; $X$-the set of experts
**Output:** $s(k_{sel})$-the selected project status disclosure

```
Compute z^t(x) for x ∈ X
Initialize w^t(x) = max_{x∈X} z^t(x)
while t < T do
    X′ = {x : z^t(x) ≥ min w^t(x)}
    Perform a majority vote for s(k) ∈ H_{X′}
    Select s(k_sel) as the s(k) with the majority rule
    Update w^t(x) = (1 − σ)q^t(x) + σw^{t−δ}(x) if a new expert
x is selected
    Update q^t(x) and z^t(x) for each x ∈ X
end while
```

## EXPERIMENTS

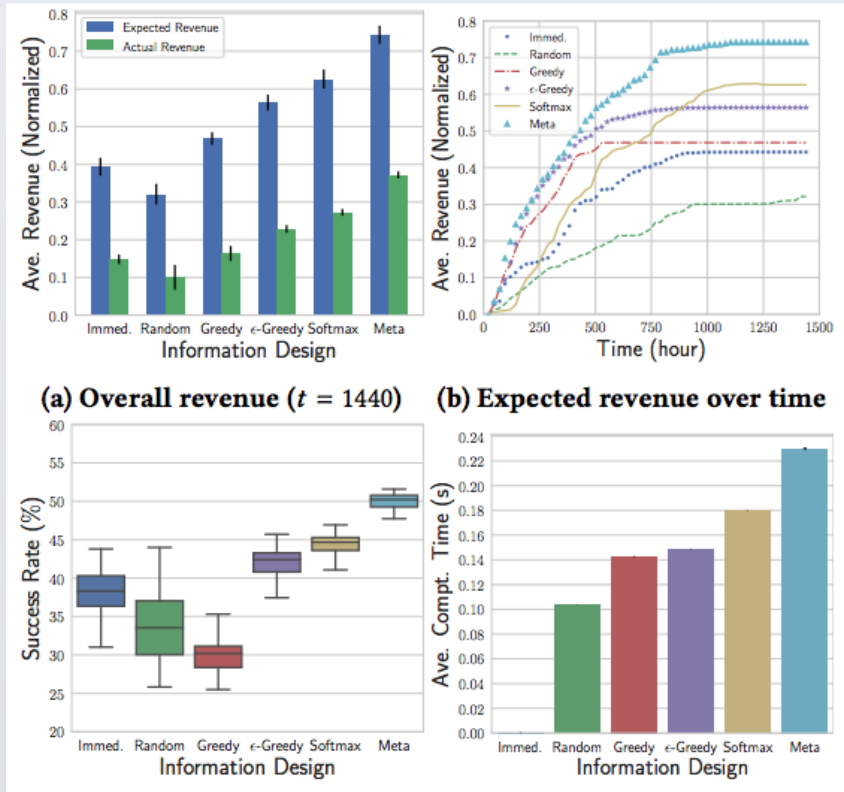
### Data

- 1,569 projects (reward-based, all-or-nothing) from Kickstarter
- Only the early-bird pledges and the regular pledges were selected.
- Backers' arrivals: Poisson distribution (i.i.d. with different means)
- Backers' estimate of probability of success: anticipating random walk.
- Backers' valuation of a reward: Gaussian distribution with a mean of the value of the reward.

### Procedure

- Six groups: immediate disclosure, random, greedy, ∈-greedy, softmax and meta.
- Each group was run 30 times on the same 2.9 GHz quad-core machine.

## RESULTS&CONCLUSION




(a) Overall revenue ($t$ = 1440) (b) Expected revenue over time
(c) Project success rate (%) (d) Computation time

### Observations

- Meta group performed consistently the best among all the groups in terms of both actual and expected revenue.
- Meta group had the highest project success rate.
- Meta group required the most computational time.

### Implications

- Immediate disclosure is not always optimal in crowdfunding when backers use cutoff policies
- The entrepreneur can benefit from dynamic information design with appropriate heuristics.

### Conclusion

- We present the first study on information design where a sender interacts with multiple receivers that follow thresholding policies.
- We demonstrate how the entrepreneur can benefit from dynamic information design with simple heuristics.

### Future Directions

- Extensions to other domains (e.g., online shopping, transportation systems, smart grids)
- Information design when agents use other decision models (e.g., no-regret learning).

## KEY REFERENCES

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