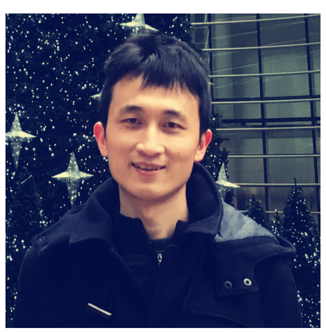
Information Design in Crowdfunding under Thresholding Policies



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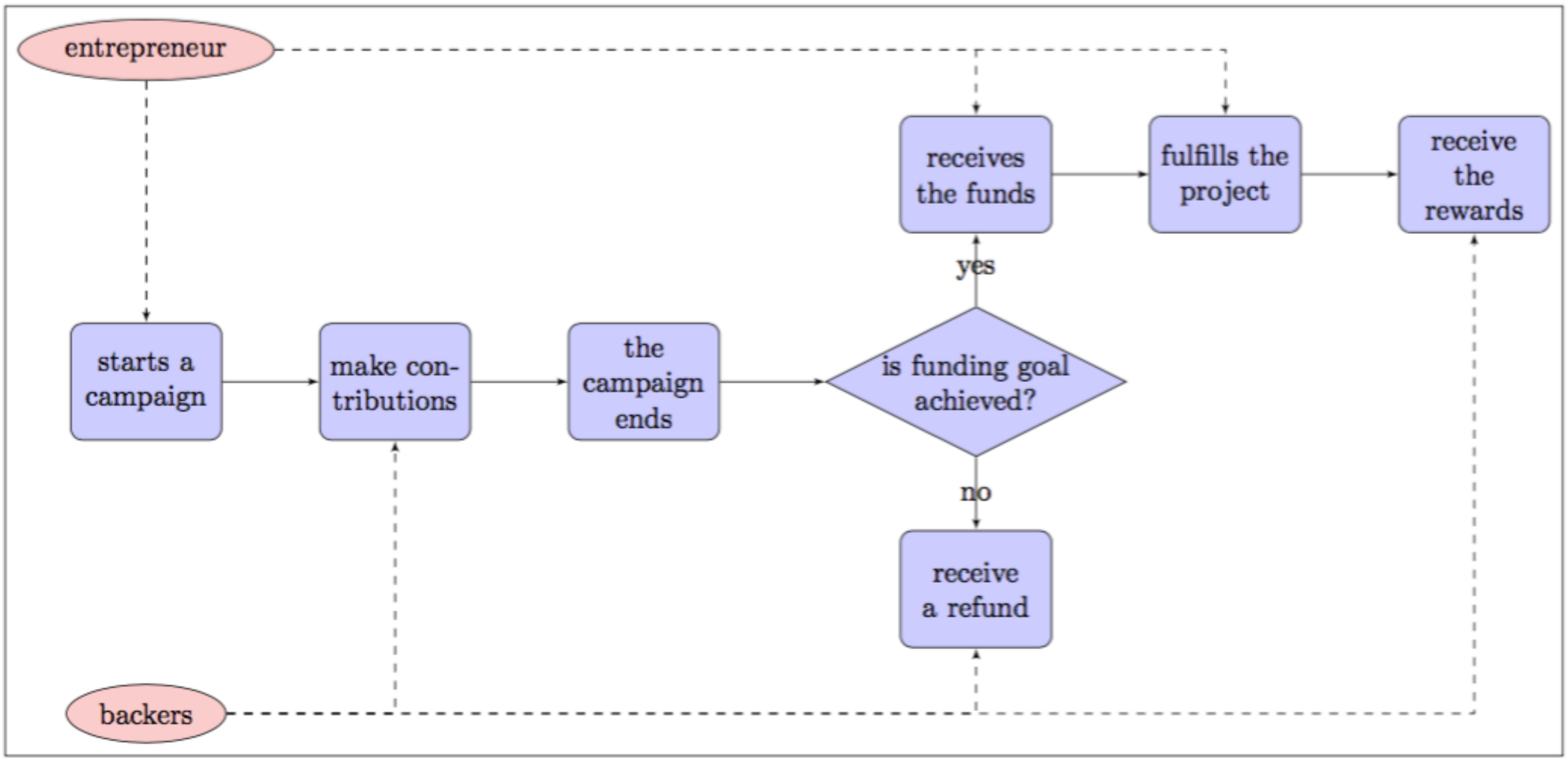
Crowdfunding Revolutionizes Fundraising

VS

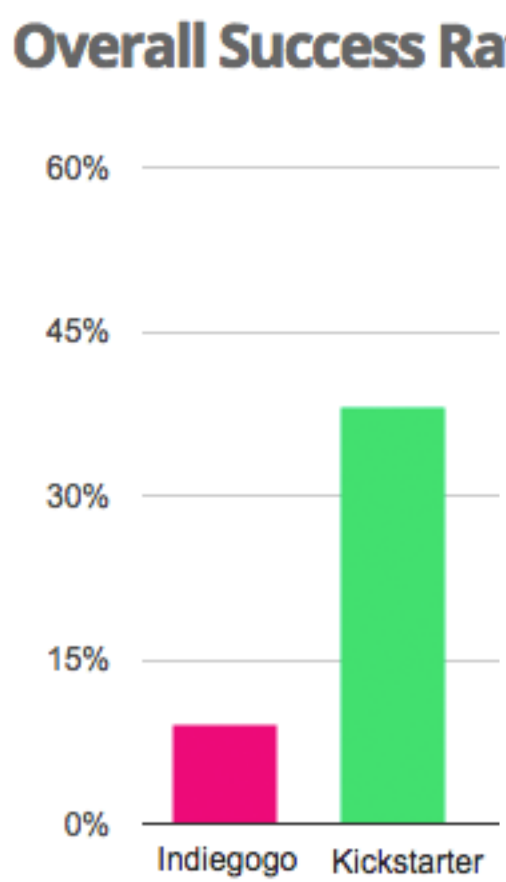
Traditional fundraising
- large amount from few sources
- can be sophisticated

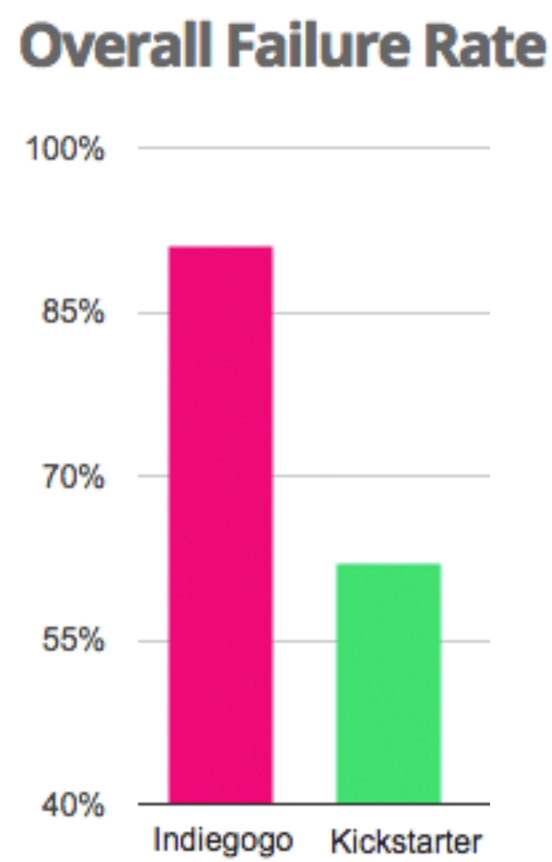
Crowdfunding
- small contributions from many individuals
- easy and simple

A Typical Campaign



Most Campaigns Failed





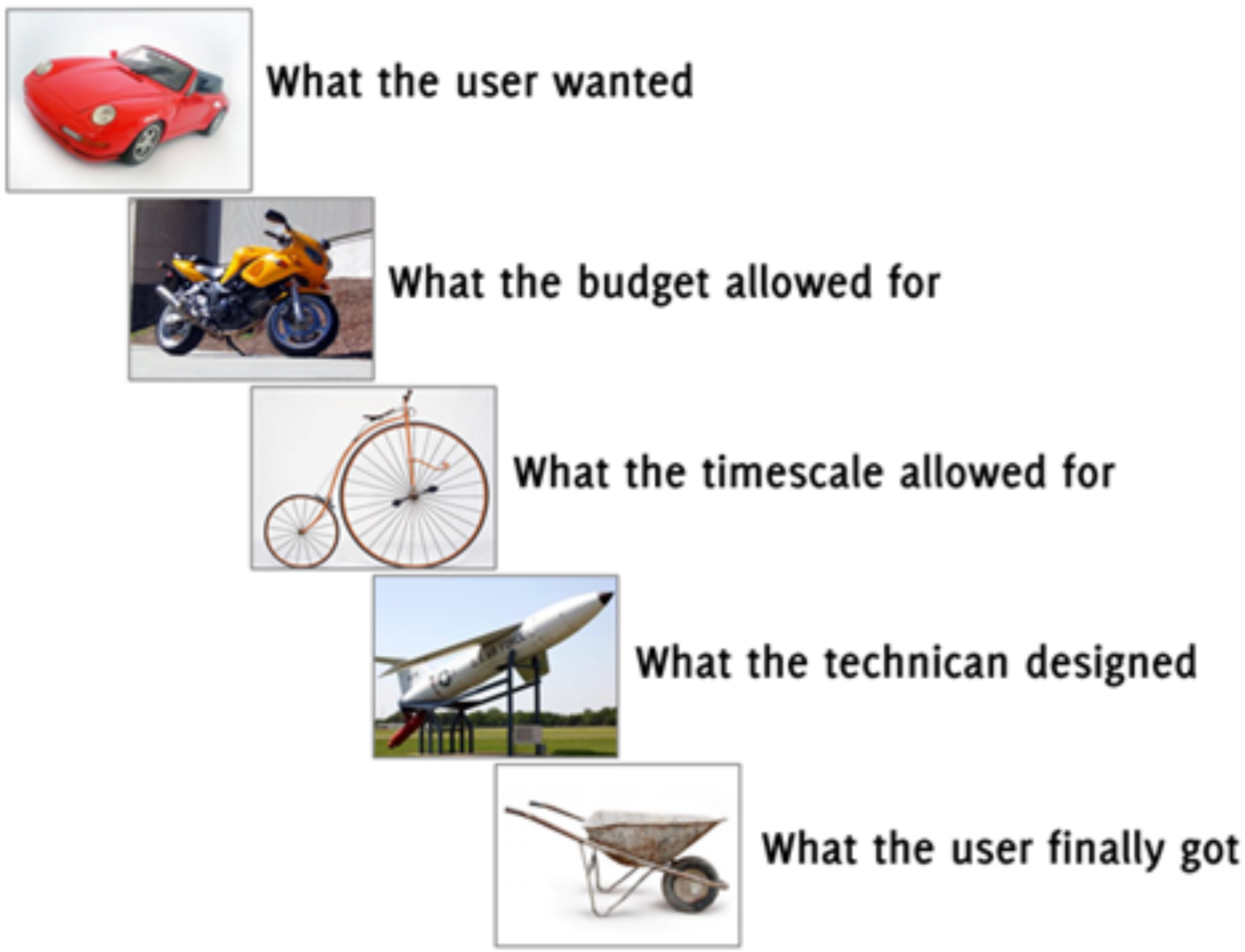
Observation: Less than **40%** campaigns succeeded.

Why did Campaigns Fail?

Reasons:

- **Early contributions** are crucial to the success of a campaign: signaling; and information diffusion.

- Backers are often reluctant to contribute in the early days of a campaign due to **high uncertainty** (e.g., the probability of success that the campaign will get funded or the award will be delivered).



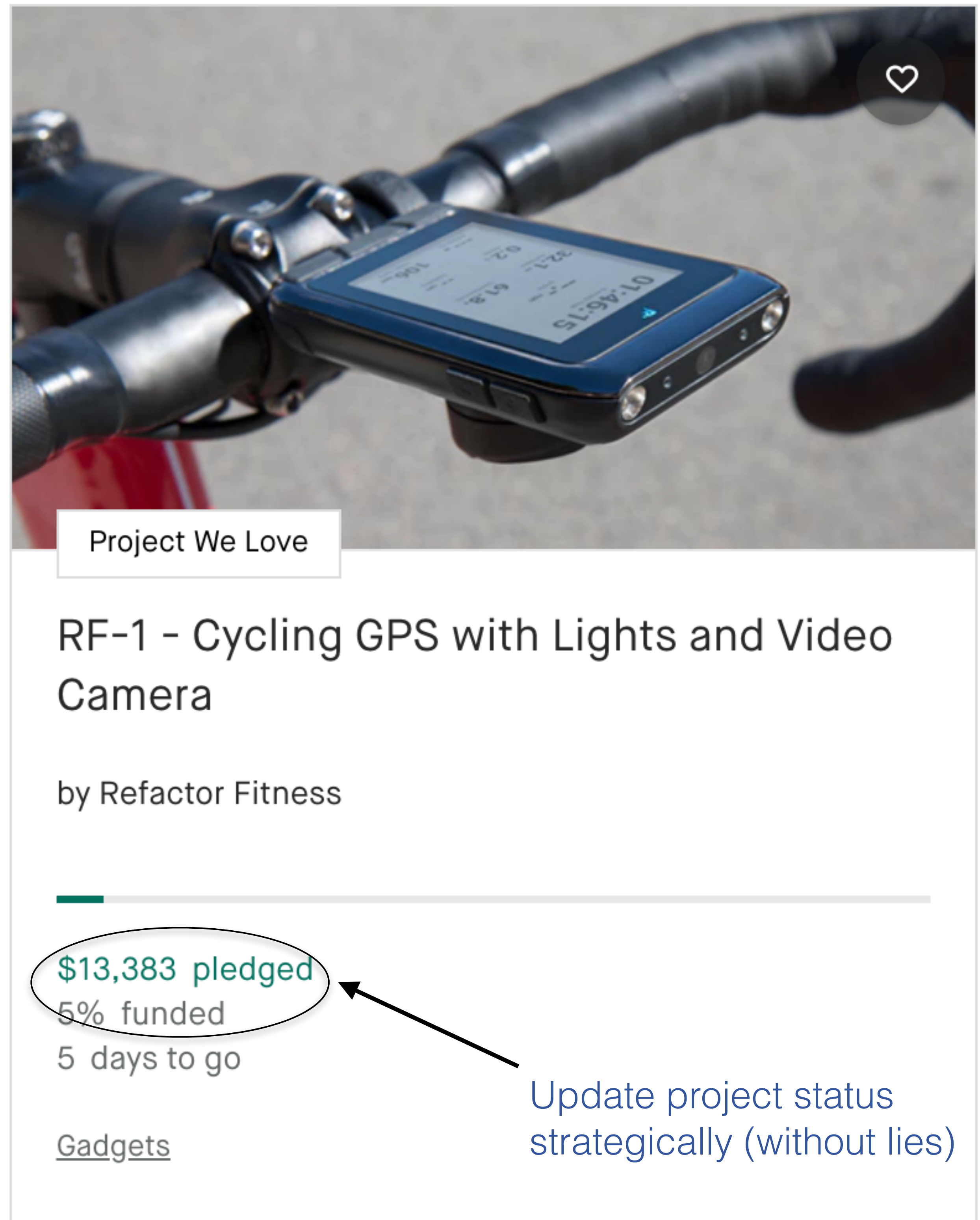
Solution:

- Attracting as many **early contributions** as possible.

Information Design

- Definition: the approach of designing **information structures** that determine which pieces of information are disclosed to whom for desirable outcomes.

- In the context of crowdfunding: the entrepreneur can voluntarily disclose the **project status** (i.e., how many contributions have been collected up to a given timestamp).



Decision Models

- Backers
  - Use cut-off policies to determine whether to contribute or not ($\alpha_i(t)$) to maximize his utility u_i :

the entrepreneur's decision on information disclosure for backer i at time t.

backer i's expected utility if he contributes.

backer i's estimate of the campaign's probability of success given the report d(i, t).

$$u_i(t, \alpha_i(t), d(i,t)) = \begin{cases} c_i \cdot \alpha_i(t) \ , & \text{if } r_i(t, d(i,t)) \geq \phi_i; \\ 0 \ , & \text{otherwise.} \end{cases}$$

backer i's threshold for contributing to the project.

discrete time t

backer i's decision on whether to contribute or not at time t.

Decision Models (Cont.)

- The entrepreneur
  - To set the disclosure policies ($DP(t) = (((d(i,t'))_{i \in \mathcal{I}(t')})_{t' \le t}$) such that the number of contributions ($M(t)$) is maximized until a given time T.

backer i's decision on whether to contribute or not at time t'.

the deadline

the number of reward

$$M(t) = \sum_{t'=1}^{t} \sum_{i \in \mathcal{I}(t')} \alpha_i(t') \cdot P \quad \text{s. t. } G, T, N, P \ .$$

the group of backers who have arrived at the campaign before or at time t', have at least one time period to leave and have not yet claimed a contribution.

the minimal amount of contributions for a reward

the fundraising goal

Key concepts

- Blackwell's theorem
  - If a piece of information ζ_1 is Blackwell-inferior to ζ_2 , then an agent will always weakly prefer ζ_2 to ζ_1.
- Categories 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 receivers' types.

Order of Project Status Reports

- An earlier report of project status is always weakly preferred if the project status of the two reports are the same.

- A later report of project status is always weakly preferred if the revenue increases by more that one contribution each time between the period of the two statuses.

Excessive Disclosure Shrinks Revenue

- Excessive information disclosure weakly diminishes the chance that a backer will contribute.
    - If the order of two project status reports can be identified, the low-order report does not increase the chance of backers' contribution.
    - If the partial order of the two project status reports cannot be identified, excessive information disclosure weakly decrease backers' projections of the campaign's probability of success.

Immediate Disclosure is not Always Optimal

- 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.

- After the campaign reachers the fundraising goal, immediate disclosure is optimal.

Dynamic Information Design

- Dynamic Shrinkage with Heuristic Selection (DSHS)
  - Dynamic Shrinkage
    - Rank all the available choices.
    - Removes the least promising choices which are less preferred by the backers.
  - Heuristic Selection
    - Use simple heuristics to select the final choices: random selection, greedy selection, ϵ-greedy exploration, softmax exploration.

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 $t \leq T$ **then**
    for each backer $i \in \mathcal{I}(t)$ **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 $d(i,t) \leftarrow (s(k_{sel}), t)$
        else ▷ after success
            Disclosure current status, i.e., $d(i,t) \leftarrow (s(t), t)$
        end if
        Update revenue $M(t+1) = M(t) + \alpha_i(t) \cdot P$
        Update project status $s(t+1) = M(t+1)/G$
    end for
end if

Dynamic Information Design (Cont.)

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
```

Dynamic Information Design (Cont.)

- Intuition
    - Improve the quality of decisions by using the experts that have a **satisficing** performance for producing the final results.
    - Use an **ensemble** approach to calculate the final selection instead of directly applying the results produced by the selected experts.

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
```

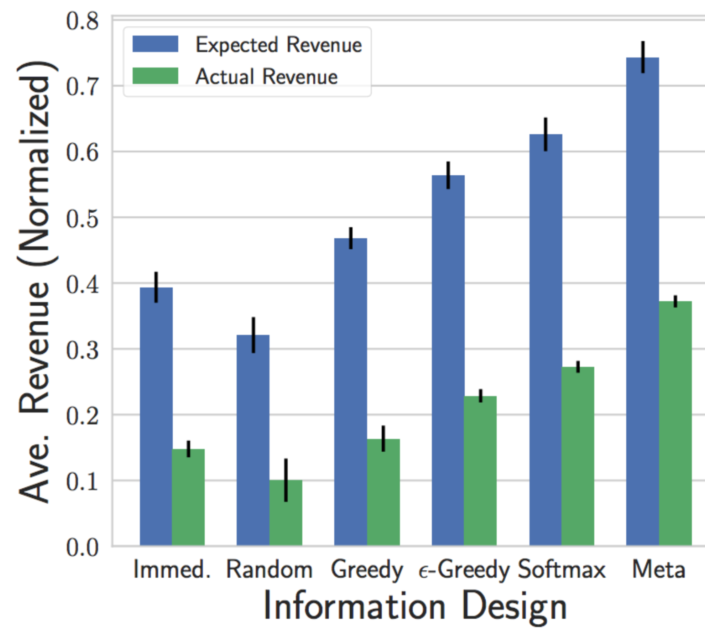
- Benefits:
    - Reduce potential performance loss due to biases of a single individual expert.

Experimental Settings

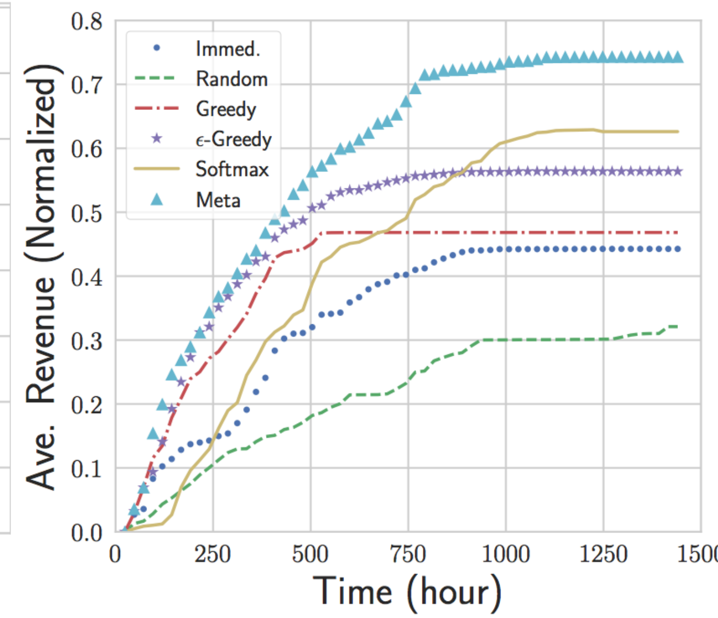
- Data
  - **1,569** projects (reward-based, all-or-nothing) from Kickstarter
  - Only the **early bird** pledges and the **regular** pledges were selected.
  - Backers' arrivals: **Poisson** distribution (i.i.d. with different means)
  - Backers' estimate of Probability of Success: **anticipating random walk**.
  - Backers' valuation of a reward: **Gaussian** distribution with a mean of the value of the reward.
- Experiments
  - Six groups: **immediate disclosure**, and DSHS with five heuristics (**random** selection, **greedy** selection, **epsilon-greedy** exploration, **softmax** exploration and **meta**.)
  - Each group was run **30** times on the same 2.9 GHz quad-core machine.

Results

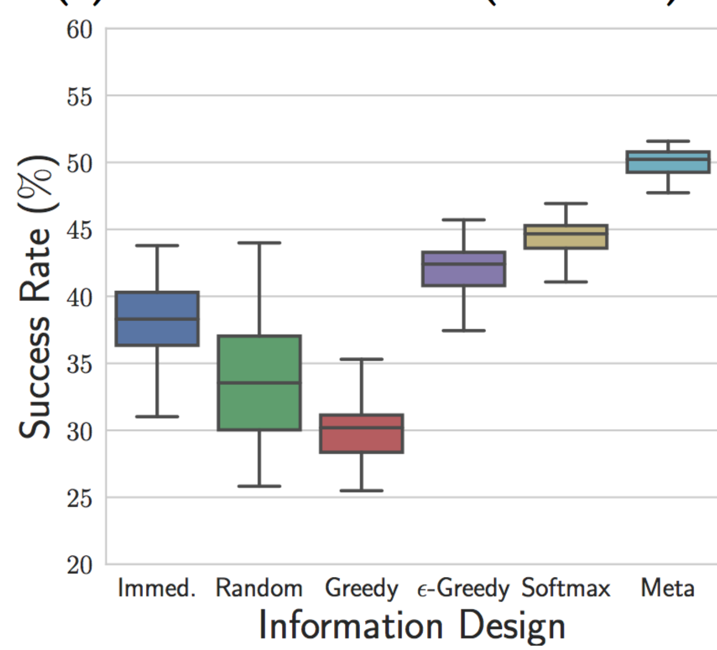
- Observations
  - Meta group performed consistently the best among all the groups in terms of both actual and expected revenue.
  - Meta group had the highest project success rate.
  - Meta group required the most computational time.
- Implications:
  - Immediate disclosure is not always optimal in crowdfunding.



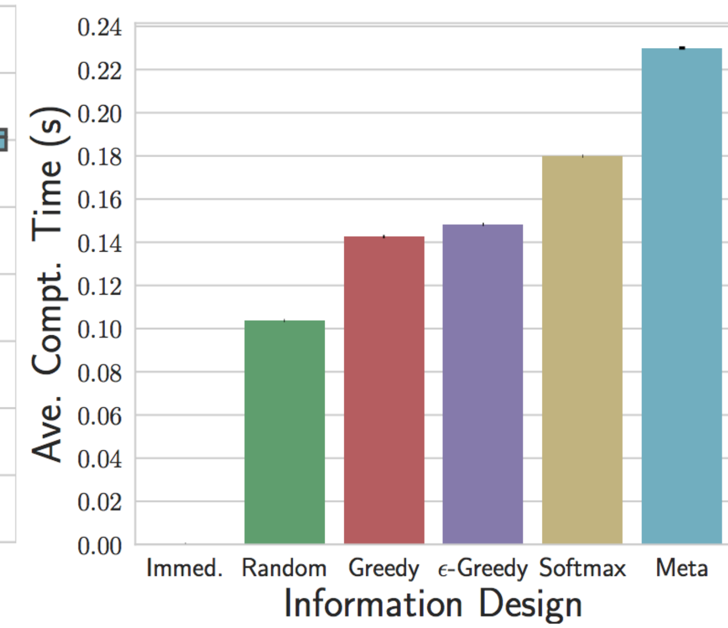
(a) Overall revenue ($t = 1440$)



(b) Expected revenue over time



(c) Project success rate (%)



(d) Computation time

Conclusions

- Our contributions
  - We present the first study on information design where a sender interacts with multiple receivers that follow thresholding policies.
  - We also demonstrate how the entrepreneur can benefit from dynamic information disclosure with appropriate heuristics.
- Messages to take away
  - Excessive information disclosure weakly shrinks the revenue in crowdfunding when backers use cutoff policies.
  - The widely-adopted immediate-disclosure policy is not optimal.
- Future Directions
  - Extensions to other domains (e.g., online shopping marketplace, transpiration systems, smart grids).
  - Information design when agents use other decision models (e.g., no-regret learning).

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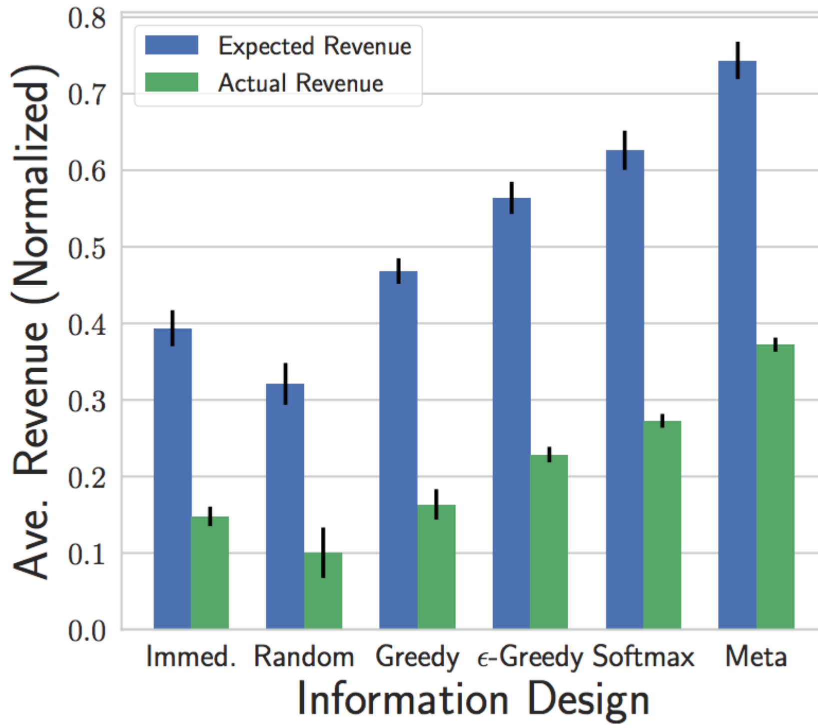

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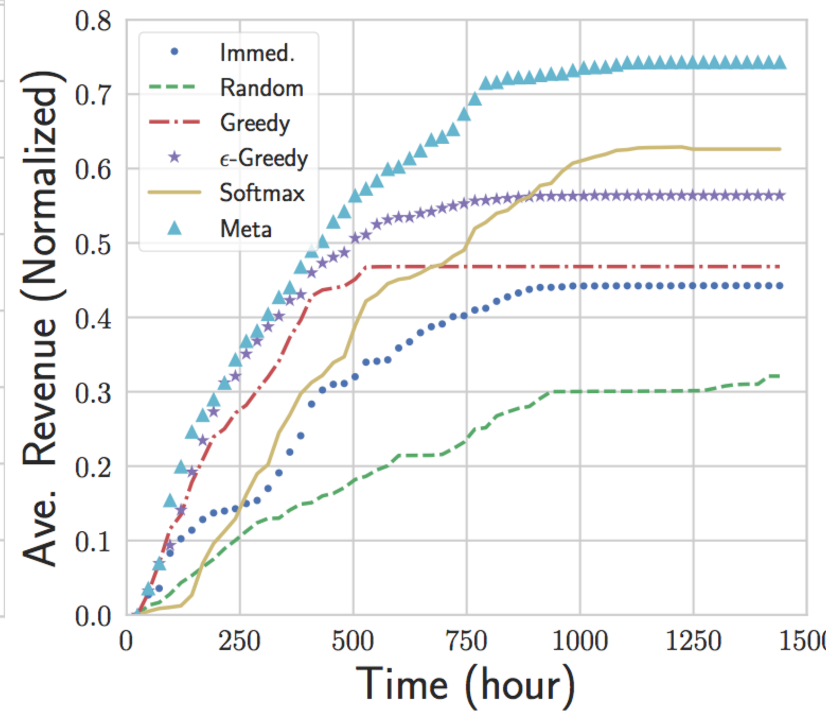

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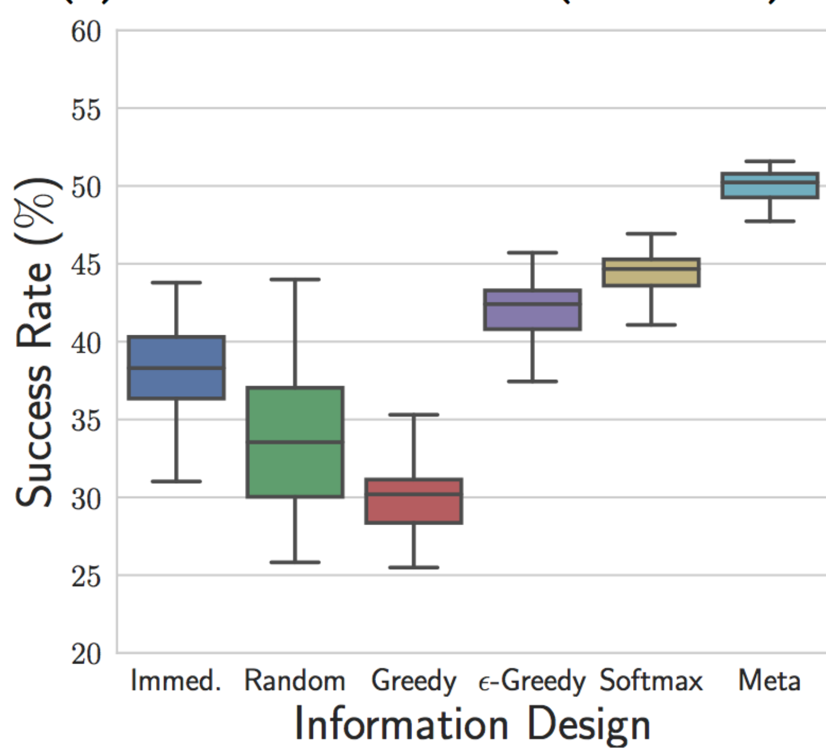

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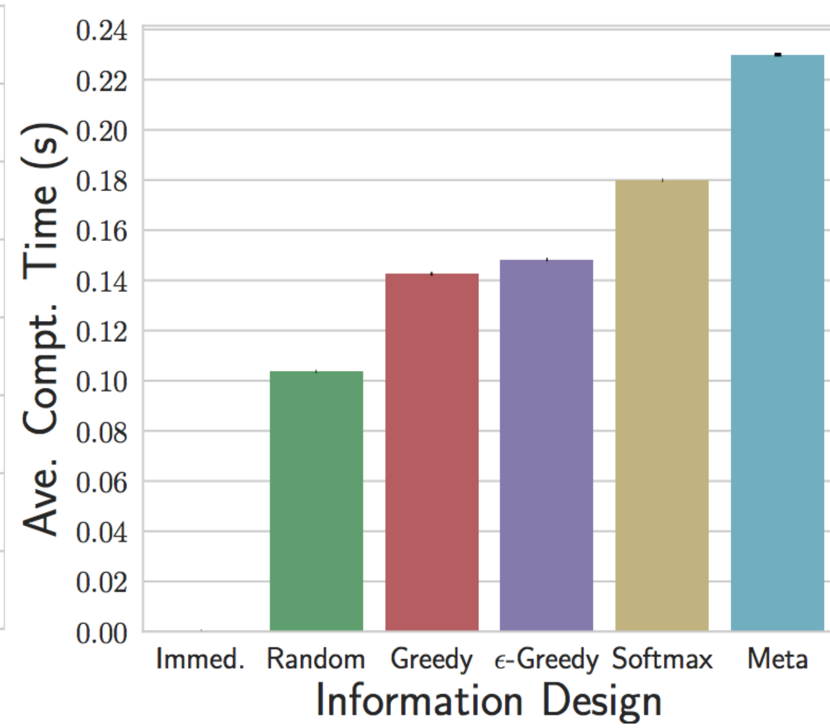

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