A Theory of Crowdfunding Dynamics

Matthew Ellman [1]   Michele Fabi [2]

[1]Institute for Economic Analysis (IAE-CSIC) and BSE

[2]Ecole Polytechnique, CREST, IP Paris

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What is Crowdfunding?

Crowdfunding:

Open call to many small contributors (usually online).

Reward-based crowdfunding:

- Funders buy a product that the entrepreneur will produce *after* the campaign.
- Crowdfunding is a form of pre-selling to cover production costs.
- Funders bid the price of the crowdfunding product.
  (we call them bidders)

Reward-Based All-or-Nothing Crowdfunding

Canonical format

- *Aggregate Fund Threshold*: funding goal
- *AoN*: succeeds if funds reach goal by deadline, else fails

$\mathcal{S}$ (success) $\rightarrow$ Bids paid, production occurs, rewards delivered;
$\mathcal{F}$ (failure) $\rightarrow$ Bids reimbursed, no production.

- Reward-based AoN crowdfunding is a popular choice because:

  It is easy to initiate in practice;

  Gives to entrepreneurs a market-test that protects from demand uncertainty.

Popular reward-based crowdfunding platforms

- Kickstarter (US)
  235 ML financed projects, 7 BN USD raised from 2009 as of 2023.
- Indiegogo (US)
  800 K financed projects, 2 BN USD raised since 2009 as of 2023.
- Kisskissbankbank (FR)
  33 K financed project, 150 ML EUR raised from 2009 as of 2023.
- Verkami (SP)
  12 K financed projects, 50 ML EUR raised from 2010 as of 2023.
- Produzioni Dal Basso (IT)
  8 K financed projects, 23 ML EUR raised from 2005 as of 2023.

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  (Recently announced future integration with the blockchain Celo)

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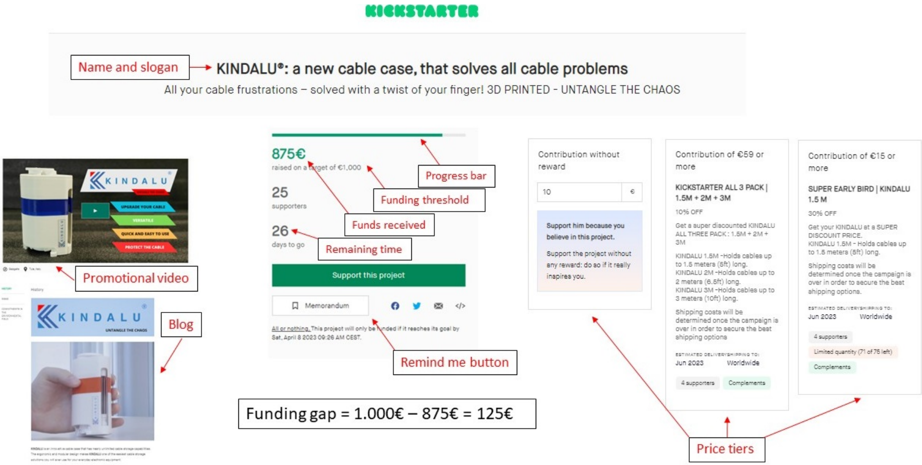
There is also crowdfunding taking place outside big platforms.

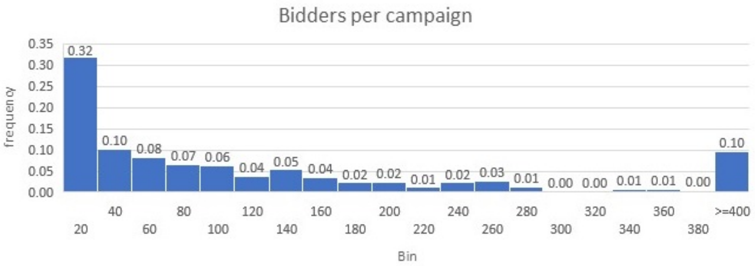
(Radiohead's album "In Rainbows" was financed with crowdfunding in 2007 directly on the band's website)

Anatomy of a crowdfunding campaign



Statistics from Kickstarter

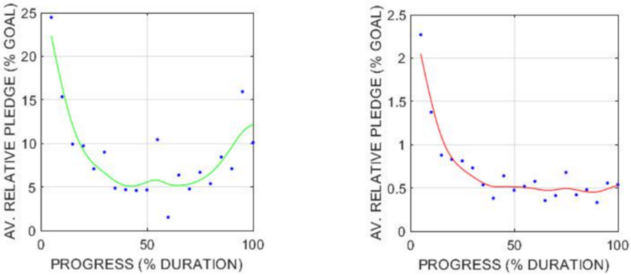
- Bids:
  Heavily right-skewed funding distribution:
  60 bidders in median, most bidding once per campaign.



- Duration: often 30 or 60 days.
- Goal: 5 K USD in median (median pledge: 25 USD),
  but heterogeneous across categories:
  (bigger for technology, games, design; smaller for music, food, crafts).
- Success rate: 30-40%.

Empirical puzzle

- Average time profile of bids is a "U-shape" for successful campaigns and an "L-shape" for failed campaigns.



Bidding (as threshold percentage) over time. Bids averaged over all 03/01/2014-02/05/2014, Kickstarter campaigns, conditioning on success (in green), failure (in red).

- What incentives drive these patterns?
- Can we use them to assess the welfare implications of current crowdfunding practices?
- Can we use them to optimize platform and campaign design?

Determinants of bidding dynamics

- Bid dynamics originate when production uncertainty faced by bidders combines with sunk bidding costs:

- *Aggregate Fund Threshold*: funding goal $\implies$ strategic complementarity
- *AON*: succeeds if funds reach goal by deadline, else fails

$$\mathcal{S} \text{ (success)} \to \text{Bids paid, production occurs, rewards delivered;}$$
$$\mathcal{F} \text{ (failure)} \to \text{Bids reimbursed, no production}$$
$$\implies \text{no sunk costs in prior works}$$

- But inspection involves sunk costs.

- So real-time disclosure of bidding aggregates creates dynamic interactions:

- Bidders sunk the bidding cost only if their estimate of the campaign's success probability is sufficiently high.

Contribution of this paper

- Characterize co-evolution of bidding and project success rates.
  - Pivotality often substantial given sequential moves
    (30% of campaigns attract < 20 bids)
- Welfare implications of funding disclosure (transparency).
- Optimal price and threshold.
- Price dynamics via price menus with limited quantities.

Closest Papers

- Alaei et al (2019)
- Deb et al (2021)
- Ellman & Hurkens (2019)

Model

Campaign

- Price p
- Bidder gap $g_0 \in \mathbb{N}_+$.
  (everyone pays the same price: funding gap $\rightarrow$ bidder gap)
- deadline $\tau \in \mathbb{R}_+$ (outcome determined at τ_+).
- Time $t \rightarrow$ time left $\tau - t$

Bidders

- Poisson arrival rate λ of bidders over $[0, \tau]$
- Valuations $v_t = \begin{cases} v & q \\ 0 & 1-q \end{cases}$
- Inspection costs c_t drawn from CDF $F(\cdot)$ on $[0, q]$

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Strategies and equilibrium

- Bidder t observes the funding state (t, g) on arrival
  - He also knows $(\mathbf{c_t}, g_0, \tau, p, \lambda, q)$

- Success probability — (funding) state (t, g):

$$S_{(t,g)} \triangleq \mathbb{P}(\mathcal{S} | (t, g)) \equiv \mathbb{E}_{(t,g)} \left(\mathbb{1}_{g_{\tau_+} \leq 0} \right)$$

- Strategies $a : (t, g, c) \to \{\mathbf{A}, \mathbf{B}, \mathbf{C}\}$ and their expected payoffs
  - **A** — no inspection, no bid $\to U^{A}_{(t,g)} = 0$
  - **B** — no inspection, bid
  - **C** — valuation-contingent bid $\to$

$$U^{\mathbf{C}}_{(t,g)} = q S^{\text{bid}}_{(t,g)} d - c_t \qquad d = v - p \qquad S^{\text{bid}}_{(t,g)} = S_{(t,g-1)}$$

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Equilibrium

Unique PBE; threshold strategies:

C if $c_t \leq qS^{\text{bid}}_{(t,g)} \triangleq qS_{(t,g-1)}$, else **A**.

Bidding rate: $\beta_{(t,g)} = \lambda q F\left(qS^{\text{bid}}_{(t,g)}\right)$.

Success rate

Using terminal conditions, $S_{(\tau,g)} = 0$ for $g > 0$, $S_{(\tau,g)} = 1$ for $g \leq 0$,

$$S_{(t,g)} = \int_t^{\tau} \left[\exp\left(-\int_t^x \beta_{(u,g)}\,\mathrm{d}u\right)\beta_{(x,g)}\right] S_{(x,g-1)}\,\mathrm{d}x \qquad \text{(REC-}S\text{)}$$

- (REC-S) is an opaque expression, so we use stochastic calculus and a martingale insight to disentangle it.

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Bidding rates

- Two effects describe the evolution of bidding rates from an initial date t, at a known gap g, to a future date x with a stochastic future gap g_x:

$$\mathbb{E}_{(t,g)}\left(\beta_{(x,g_x)}\right) - \beta_{(t,g)} = \lambda q \left[\mathcal{E}_x^{(t,g)} + \mathcal{N}_x^{(t,g)}\right]$$

Decreasing pivotality (DP)

- By LIE, $S_{(t,g_t)}$ is a martingale w.r.t. to the natural filtration of g_t. That is,

$$\mathbb{E}_{(t,g)}\left(S_{(x,g_x)}\right) = S_{(t,g)}$$

- On the other hand, *Pivotality*,

$$\Delta S_{(t,g_t)} \triangleq S_{(t,g_t-1)} - S_{(t,g_t)}$$

is a supermartingale (decreases in expectation).

- Strategic complementarity falls (on average) since a later bidder expects to have fewer bidders arriving after him.

- Combining the two insights, the bid-conditional success rate

$$S^{\text{bid}}_{(t,g_t)} = S_{(t,g_t)} + \Delta S_{(t,g_t)}$$

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Pivotality effect (PE)

- The first is the **pivotality effect (PE)**: $\mathcal{E}_x^{(t,g)}$.
- PE is the effect of the *expected* decreasing pivotality trend.
- It is *always* negative or null (in trivial cases).

$$\mathcal{E}_x^{(t,g)} \triangleq F\left(\mathbb{E}_{(t,g)}\left(qS_{(x,g_x)}^{\text{bid}}\right)\right) - F\left(qS_{(t,g)}^{\text{bid}}\right)$$

News effect (NE)

- The second effect is the **News effect (NE)**: $\mathcal{N}_x^{(t,g)}$.

- NE is the effect of the **variance** in the funding gap:
  Bidding is stochastic simply because of preference shocks and random arrivals.
  Bidders learn good or bad news depending on the gap they observe upon arrival.

- NE is determined by the sensitivity to news of the bidder population:
  - Null NE with linear cumulative inspection cost distribution F
  - Negative NE with a concave F ($\downarrow$ returns to good news)
  - Positive NE with a convex F ($\uparrow$ returns to good news)

- Technically, the sign of the NE results from Jensen's inequality:

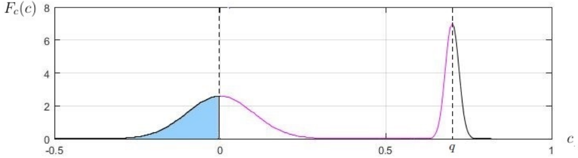
$$\mathcal{N}_x^{(t,g)} \triangleq \mathbb{E}_{(t,g)}\left(F\left(qS_{(x,g_x)}^{\text{bid}}\right)\right) - F\left(\mathbb{E}_{(t,g)}\left(qS_{(x,g_x)}^{\text{bid}}\right)\right)$$

- Combining the two effects:

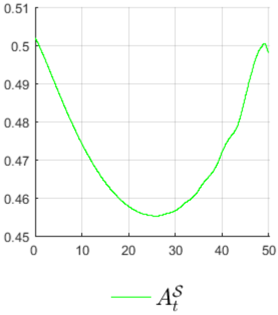
  $\implies$ Bid rate falls with concave or linear F

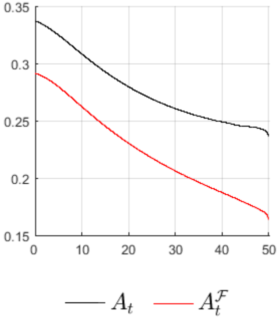
  $\implies$ Bid rate rises with convex F if $|\mathcal{N}| > |\mathcal{E}|$

Empirically salient funding patterns



Density





Welfare

Welfare: $W = V + RS_0$

- We assume E's utility from success = R & neglect revenues.
- Realized arrival sequence $\{t_n\}$, $n = 1, 2, ..., N$.
- Bidder surplus:

$$V = \mathbb{E}\left(\sum_{n=1}^{N} u^{a(t_n,g_n,c_n)}\right) \underbrace{=}_{\text{Poisson arrivals}} \lambda\tau\mathbb{E}\left(U_{(t,g_t)}^{a(t,g_t,c_t)}\right)$$

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Equilibrium of SIM

- In the baseline model the gap is disclosed in real time.
- Is transparency good for welfare?
- To answer this question, we compare our baseline (SEQ) to a no-information benchmark (SIM).

- In SIM, bidders arrive sequentially but do not observe g_t.
- Equilibrium strategies use a constant threshold type $\hat{c}_{(t,g)} = \hat{c}$

Welfare comparison of SIM and SEQ

- While in SIM surplus contributions are constant over time, in SEQ they decrease.
- DP and NE manifest themselves also in the welfare analysis:
  1. (infra-marginals): Surplus of types $c_t \leq \hat{c}$ decreases due to DP.
  2. (semi-marginals): good-news effects from a bid activates types $c_t \in \left(\hat{c}_{(t,g)}, \hat{c}_{(t,g-1)}\right]$.
- SEQ yields higher welfare than SIM for polarized inspection costs.
- SIM yields higher welfare than SEQ when inspection costs are sufficiently concentrated (homogenous case).
- Intermediate information structures can improve on both SIM and SEQ.

Conclusion

Main takeaways

- Characterization of bidding profiles with 2 new forces: pivotality and news effects
  - These effects combined with heterogeneous costs explain observed bidding profiles.
- Cost diversity and adverse conditions can explain real-time disclosure.
  - Partial disclosure can raise welfare
- Framework reveals price-threshold tradeoff, identifies optimal price dynamics, and allows for study of welfare effect of gap-dependent pricing.

Next:

- Endogenous timing via option to delay (E and F 2021).
- Common value.

Thank you for your attention!

For the paper and the blog post, scan the QR codes below:

Paper

BSE Focus