

Optimal allocation of attention in user-generated content platforms

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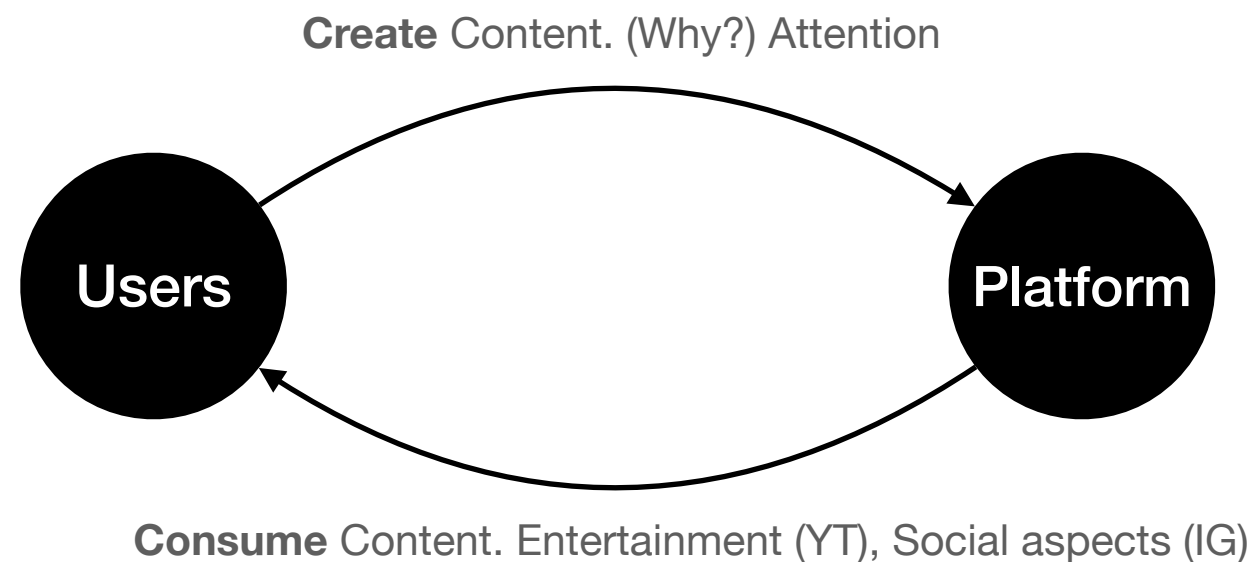
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Context

Almost everything is User-Generated Content (UGC) !

- Except for Google, the 6 most viewed websites are UGC
- Of the 10 most downloaded iPhone apps, 8 are UGC (and 2 messaging services)



- Looking at the distribution of attention...
 - Some platforms opted for professionalization (few users creating most of the content consumed)
 - E.g. Twitch, Youtube... <— “High quality” content, attention concentrated at biggest creators
 - Others tried to incentivise the creation of content from all users and social interaction
 - E.g. Instagram (stories introduction), BeReal... <— “Low quality” content, attention more distributed

Introduction (I)

Question to answer in this thesis: For a monopolist platform, which is the **best way to distribute attention** across users such that they are incentivised to create content in a way that maximises its utility (profit/sum of users utilities)?

I focus in the differences between optimal allocations depending on the preferences that users have for consuming quality that has been created by different users.

Social platforms (IG, Snapchat): users prefer to consume content from a lot of creators
VS Entertainment platforms (Youtube, Twitch)... where quality comes first

Introduction (II)

Question *quite* studied in Computer Science literature but not in economics, some (big) differences:

1. CS literature **does not derive an optimal mechanism**, but study which of some (**exogenously** provided) ones is *better*
2. They **focus on the qualities** of the equilibrium, not the utility that agents derive from it or profits of the platform (there are exceptions)
3. They use **different tools**. (e.g. algorithmic game theory)

I use a “modified” **Principal-Agent** model:

The principal (a platform) allocates attention to agents (users) in exchange for them creating quality. Two differences:

1. **No monetary transfers available**: payment of attention (which is **bounded**)
2. **Utility** of any user in the platform **depends on the transfers** (attention) **paid to the rest** of users.

Outline

1. General Model (theoretical framework)
2. Binary Model (more results)
3. Ad-funded Platforms (application)

General Model: Framework

- Consider a **benevolent** platform P which has N users.
- Each user $i \in \llbracket 1, N \rrbracket$ is both **creator** and **consumer** of (quality of) content.
- Production of a unit of content has a **cost** θ_i , heterogeneous across users.

Actions

- **Users**: choose the quality of the content created $q_i \in \mathbb{R}^+$
- **Platform**: choose the attention *paid* to each user $A_i \in [0, 1]$.
 - Total attention is bounded: $\sum_{i=1}^N A_i \leq 1$.

All users consume the same content, which is decided by the platform through the allocation of attention !

Utility of each user $i \in \llbracket 1, N \rrbracket$:

Creation utility Consumption utility

$$U_i(\mathbf{A}, \mathbf{q}) = A_i - q_i \theta_i + \sum_{j \neq i} (A_j q_j)^\mu$$

- Parameter $\mu \in \mathbb{R}^+$ represents the preference for consuming (quality of) content from different creators. The lower the μ , the higher is the preference for **variety** in creators.
- In the consumption utility, I use $A_j q_j$ and not just q_j because the relevant variable is the **perceived quality**. Otherwise, users derive utility from quality they are not paying attention to.

First best problem and results

- The platform is **benevolent** in the sense that **maximises the sum of utilities** of the users.
- Complete Info: Knowing costs $\theta = (\theta_1, \dots, \theta_N)$, the platform offers a contract $\{A_i(\theta), q_i(\theta)\}$ to each user in which allocates attention A_i in exchange for the production of quality q_i

Problem of the platform:

$$\begin{aligned} \max_{\mathbf{A}, \mathbf{q}} \quad & \sum_{i=1}^N \left(A_i - \theta_i q_i + \sum_{j \neq i} (A_j q_j)^\mu \right) \equiv \max_{\mathbf{A}, \mathbf{q}} \sum_{i=1}^N U_i \\ \text{s.t.} \quad & \begin{cases} A_i - q_i \theta_i \geq 0 & (\text{IR}) \\ \sum_{i=1}^N A_i \leq 1 & (\text{Feasibility 1}) \\ 0 \leq A_i \leq 1 & (\text{Feasibility 2}) \end{cases} \quad \forall i \in \llbracket 1, N \rrbracket \end{aligned}$$

The IR only concerns creation of content

It is assumed that the platform is open-access and free and therefore any user can consume content even if it does not creates content at all

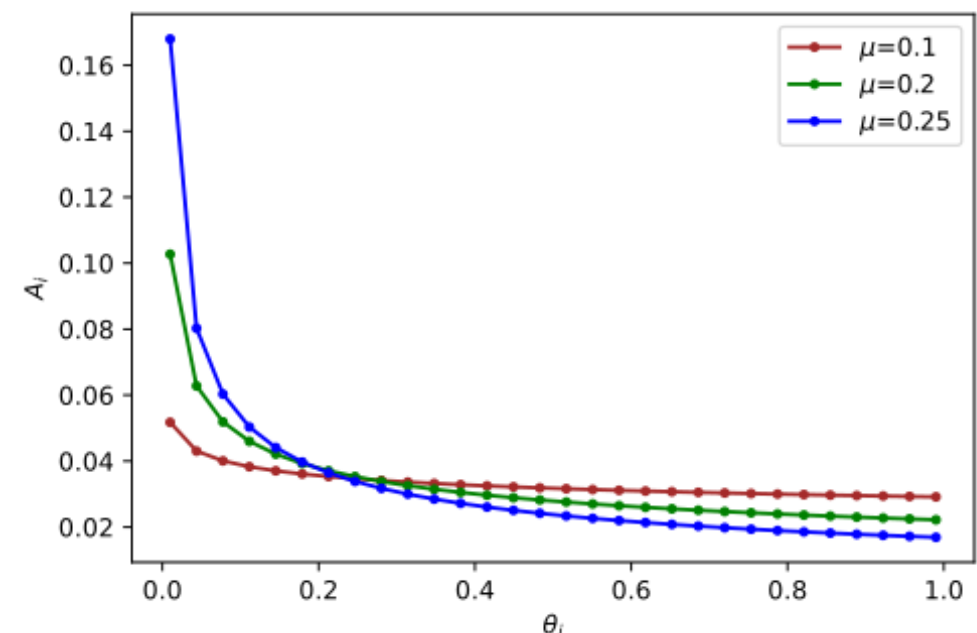
- **Lemmas 1 & 2:**

If N is large enough and $\mu \in (0, 1/2)$,
IR binds and Feasibility 2 does not.

- **Optimal attention shares and qualities:**

$$A_i^* = \frac{\theta_i^{\frac{\mu}{2\mu-1}}}{\sum_{j=1}^N \theta_j^{\frac{\mu}{2\mu-1}}} \quad q_i^* = \frac{A_i^*}{\theta_i} = \frac{\theta_i^{\frac{1-\mu}{2\mu-1}}}{\sum_{j=1}^N \theta_j^{\frac{\mu}{2\mu-1}}}$$

Example. $N = 30$ and equidistant costs.



Moreover...

- **Proposition 2:**
- In the First Best setting, the optimal attention allocation with respect to qualities follows a **Generalized Tullock Contest**:

$$A_i^* = \frac{q_i^{\frac{\mu}{1-\mu}}}{\sum_{j=1}^N q_j^{\frac{\mu}{1-\mu}}}$$

In the contests' literature, the higher $r = \frac{\mu}{1-\mu}$ the lower levels of participation but the highest top qualities

For simplicity, the **second best** setting and its relation with the first best is studied in the framework of N users divided in two types of users, L and H , that have costs $\theta_L < \theta_H$

(more elegant and tractable seems to be the case of the continuum of agents explored minimally in Appendix B, but its study is left out of this thesis)

Binary Model

(The first best is a special case of the general case)

- Platform P knows $\theta_L < \theta_H$ and proportions f_L, f_H of users of each type, but **not which type is each user**.
- Assume N is large enough such that it is admissible consider that the actual proportions are the theoretical ones and $N_k = f_k N$ for $k \in \{L, H\}$.
- The platform offers a menu of contracts $\{A_i, q_i\}_{i=L,H}$ where allocates A_i in exchange for production of q_i and each user chooses its preferred one. They are designed incentivising self-revelation through IC constraint(s)

$$\begin{aligned} \max_{A_L, A_H, q_L, q_H} \quad & N_L \left(A_L - q_L \theta_L + (N-1)(A_L q_L)^\mu \right) + N_H \left(A_H - q_H \theta_H + (N-1)(A_H q_H)^\mu \right) \quad \equiv \max_{\mathbf{A}, \mathbf{q}} \sum_{i=1}^N U_i \\ \text{s.t.} \quad & \begin{cases} A_L - q_L \theta_L \geq A_H - q_H \theta_L & (\text{IC}_L) \\ A_H - q_H \theta_H \geq 0 & (\text{IR}_H) \\ N_L A_L + N_H A_H \leq 1 & (\text{Feasibility 1}) \\ 0 \leq A_i \leq 1 & (\text{Feasibility 2}), i \in \{L, H\} \end{cases} \end{aligned}$$

Analytical solutions difficult to get! There is a numerical example next slide.

Proposition 3:

Under standard assumptions, quality of the low-cost type is distorted

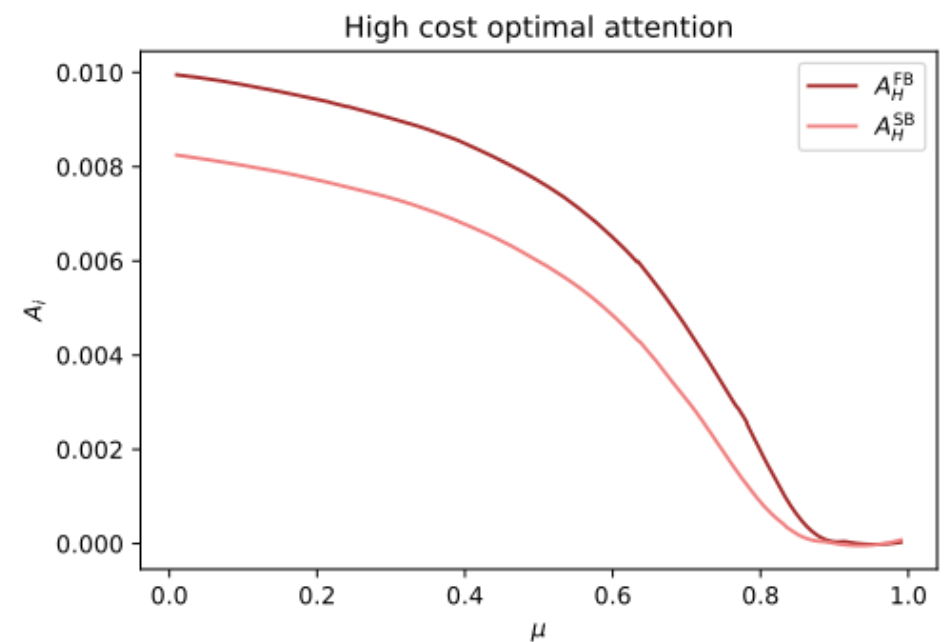
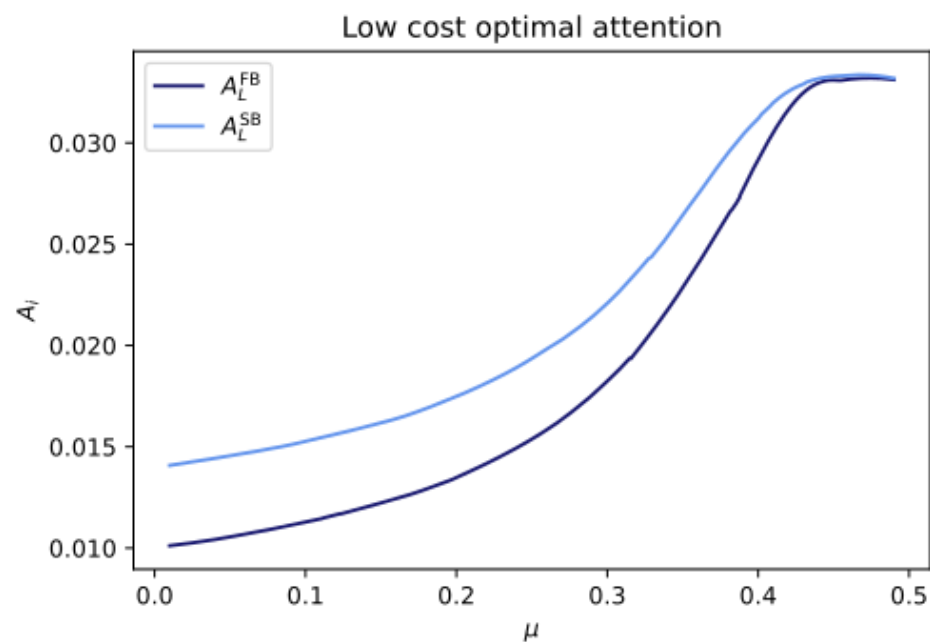
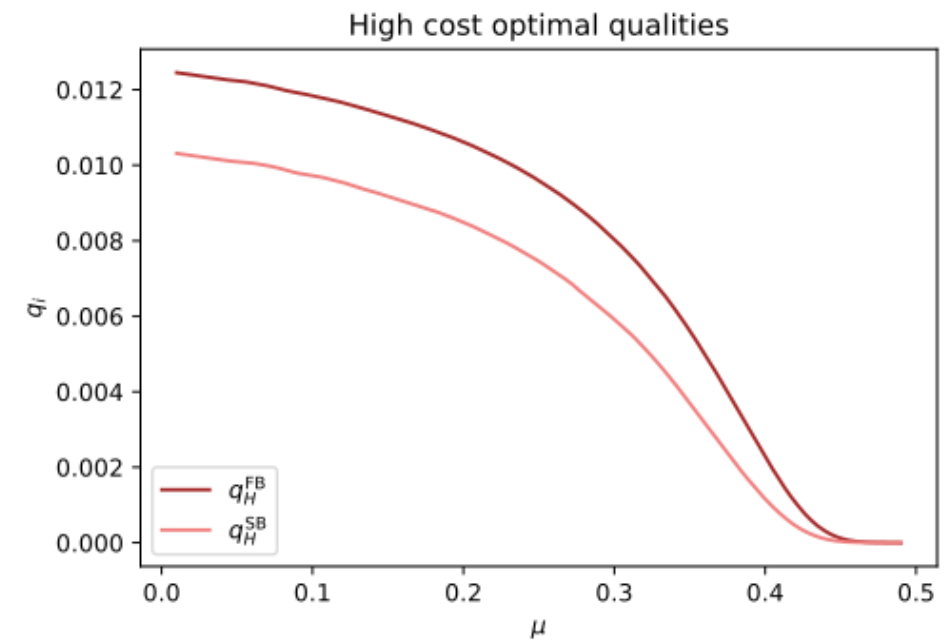
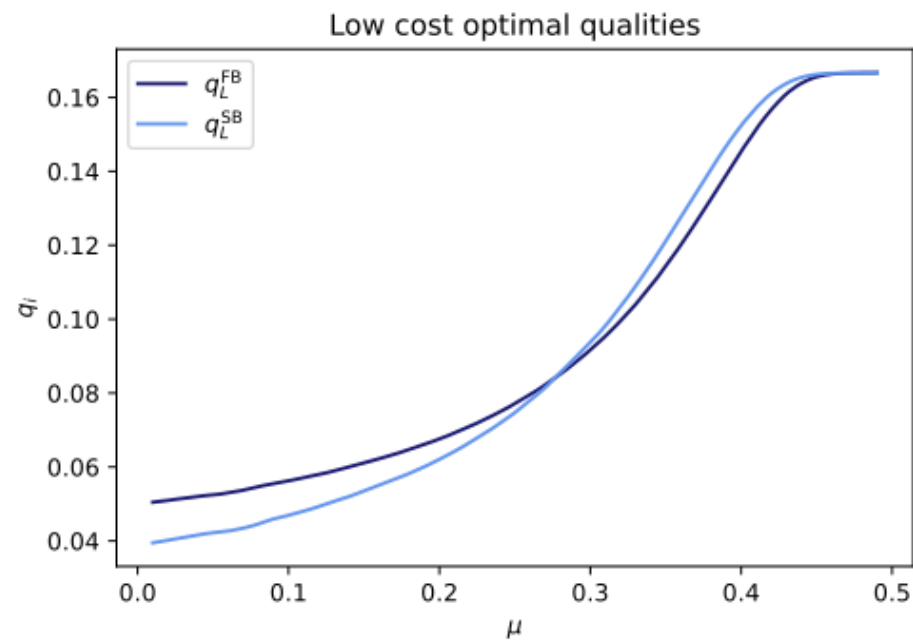
$$\exists \mu \in \left(0, \frac{1}{2}\right) : q_L(\mu)^{FB} \neq q_L(\mu)^{SB}$$

Conjecture 1:

Moreover, the direction of the distortion depends on the preference for variety μ

$$\begin{cases} q_L(\mu)^{SB} < q_L(\mu)^{FB} & \text{iff } \mu < \mu^* \\ q_L(\mu)^{SB} = q_L(\mu)^{FB} & \text{iff } \mu = \mu^* \\ q_L(\mu)^{SB} > q_L(\mu)^{FB} & \text{iff } \mu > \mu^* \end{cases}$$

Example: Numerical Solutions



Application: ad-funded platforms

- Platform P is ad-funded and maximises profit.
- Same benchmark as in the binary model: two types L, H with costs $\theta_L < \theta_H$ and proportions f_L, f_H
- Platform now allocates $A_0 \in [0,1]$ attention to ads and gets revenue from it.

Attention allocated to ads Total utility derived by users

Profit U^P is determined by:

$$U^P = \overbrace{A_0}^{\text{Attention allocated to ads}} \cdot \overbrace{\sum_{i=1}^N U_i}^{\text{Total utility derived by users}}$$

Problem of the platform:

$$\begin{aligned} \max_{A_0, A_L, A_H, q_L, q_H} \quad & A_0 \left(N_L (A_L q_L)^\mu + N_H (A_H q_H)^\mu \right) \\ \text{s.t.} \quad & \begin{cases} A_H - q_H \theta_H \geq 0 & (\text{IR}_H) \\ A_0 + N_L A_L + N_H A_H \leq 1 & (\text{Feasibility 1}) \\ 0 \leq A_i \leq 1 & (\text{Feasibility 2}), i \in \{0, L, H\} \\ A_L - q_L \theta_L \geq 0 & (\text{IR}_L) \\ A_L - q_L \theta_L \geq A_H - q_H \theta_H & (\text{IC}_L) \end{cases} \end{aligned}$$

Only in First Best

Only in Second Best

Propositions 4 and 5: Both in the first and second best settings, the **optimal allocation to ads** A_0 is

$$A_0 = \frac{1}{1 + 2\mu}$$

Does not depend on the info context !

Does not depend in any parameter but μ !

Conclusion

Takeaways:

- In complete information, distribution of attention shaped by preferences on diversity
- In the second best, qualities are distorted upwards or downwards depending on μ

Different directions in **future research**:

- Make the model continuous
- Heterogeneous μ_i across agents and platforms
- Behavioural aspects (e.g. addiction)