Streaming Platforms and Recommendation Bias

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Streaming platforms

- Provide subscribers with an unlimited access to content (music, movies, etc.) from a variety of content providers.
- Use advanced recommender systems to suggest selected, user-specific, content to their customers.
- **Recommender systems:** software tools that provide personalized suggestions to users based on past consumption, similar decisions made by other users, similarity of content products, etc.

Do consumers follow recommendations?

Some evidence that consumers do follow recommendations:

Netflix (movies, TV series)

- In 2013, according to Netflix, 75% of viewer activity originated from recommendations (Wired, 2013).

Deezer (music)

- Maillard (2015): panel of 4,000 subscribers over a 4-month period
- 85% of subscribers have followed recommendations at least once.
- 41% of activity originates from recommendations.

Recommendation bias

Streaming platforms' incentives to bias recommendations to consumers?

To favor content from larger content providers?

- "Independent labels tell Billboard that less-familiar released can lose their search rankings on digital platforms like iTunes in favor of more familiar recordings – usually from the larger labels" (Billboard, 2016).

To favor in-house content (if any)?

- "Given that Netflix is in the business of recommending shows or movies, might its algorithms tilt in favor of the work it commissions as it goes deeper into original programming?" (NYT, 2013).

Research questions

- What are the streaming platforms' incentives to bias their recommendations to consumers?
- What is the impact of (biased) recommendations on the relations between platform intermediaries and content providers?
- What is the impact on the market structure of content markets?

Literature

Search bias:

- Hagiu and Jullien (2011, 2014), de Cornière and Taylor (2014).
- Service is offered for free to users.

Bias on recommender systems:

- Calvano and Jullien (2016).

Biased advice from intermediaries/retailers:

- Armstrong and Zhou (2011), Inderst and Ottoviani (2012).
- Sellers rely on an intermediary to reach consumers. The intermediary can influence sales for one seller or the other.
- Hunold and Muthers (2012) in a manufacturer-retailer context.

Outline of presentation

1– Presentation of the model

2– Model analysis with exogenous royalty rates

3– Endogenous royalty rates

4– Conclusion

1– The model

Model

Monopoly streaming platform:

- Subscription fee F to users, no usage fee
- Makes recommendations to consumers regarding their content mix

Mass 1 of consumers:

- Heterogenous in their type x, uniformly distributed on $[0, 1]$
- Type $\rightarrow$ optimal content-mix: x from A and $1 - x$ from B
- Homogeneous in utility from optimal content-mix: v

Recommender system $\bar{x}(\cdot)$:

- User x is offered a mix which includes $\bar{x}(x)$ of content from A and thus $1 - \bar{x}(x)$ of content from B
- Disutility $|\bar{x}(x) - x|t$, with disutility parameter $t > 0$

Content providers

Upstream content providers:

- 2 content providers, A and B
- linear per-unit royalties r_A, r_B

Contracts between streaming platforms and content providers in practice (from contracts that have leaked):

- Complex formulas
- Include fixed fee payments (advances) and positive royalties

Our approximation: simple contracts with linear per-unit royalties

Assumption: platform's payments to content providers increase in quantity of content served.

Timing

The per-unit royalties of content providers A and B, r_A and r_B, are given (for the moment).

1. **Fee and recommendation algorithm** The platform set the fee F to subscribers, and its recommendation algorithm $\bar{x}(\cdot)$.
2. **Subscription** Consumers decide whether to join the platform.

Remarks:

- Both consumers and the platform are informed about about consumers' optimal content-mix.
- Outside option: non subscribers obtain a utility of 0.

2– Model analysis

Optimal recommendations

For a given F, how does the platform design its recommender system?

- Assume that $r_A \leq r_B \implies \bar{x}(x) \geq x$
- Platform's margin for consumer x with recommendation $\bar{x}$:

$$M(\bar{x}|x) = F - r_B + \bar{x}(r_B - r_A), \text{ increasing in } \bar{x}$$

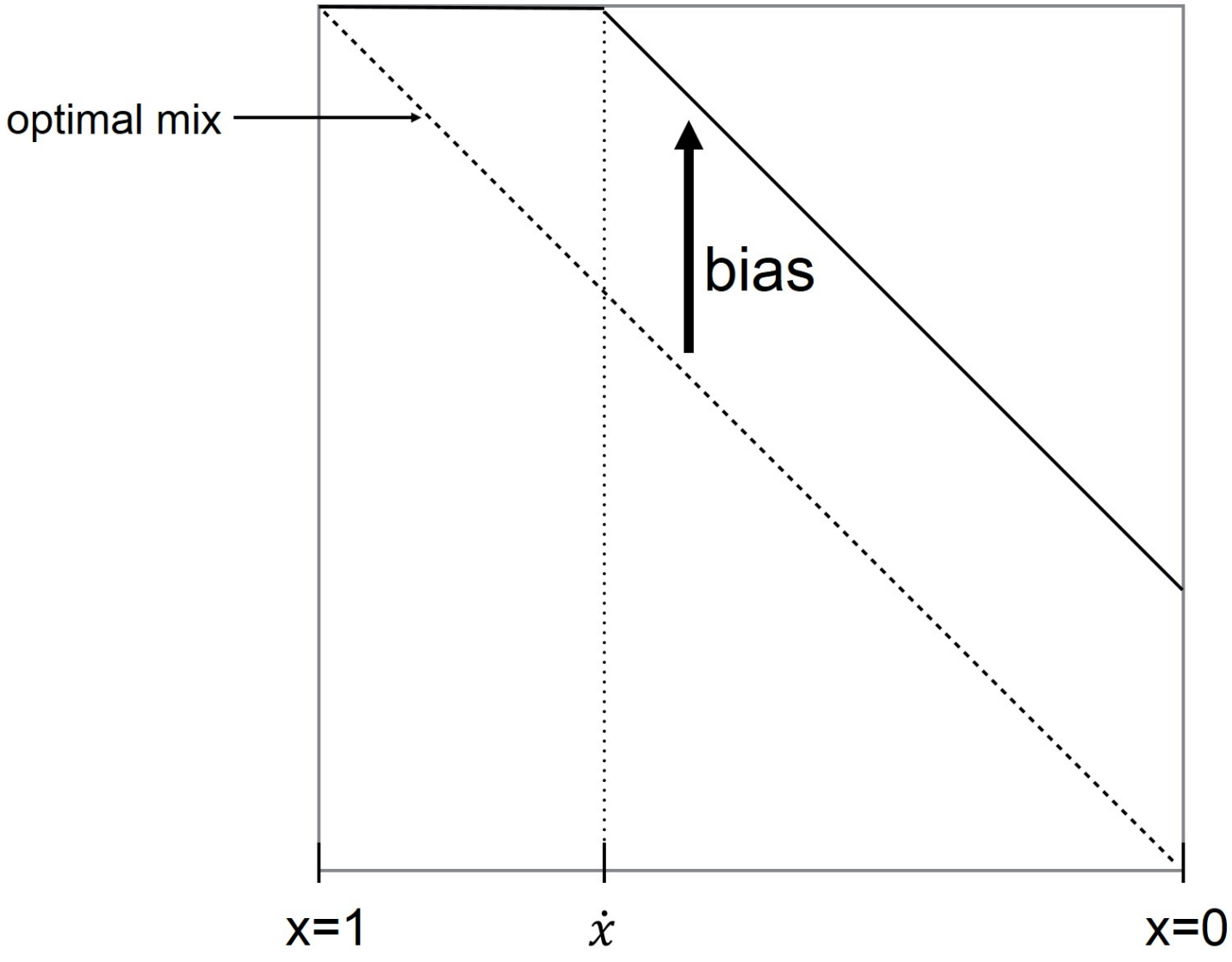
- Consumer's utility:

$$U(\bar{x}|x) = v - F - t\,(\bar{x} - x)\,, \text{ decreasing in } \bar{x}$$

- The platform therefore chooses the **highest mix** $\bar{x}$ consistent with consumer participation:

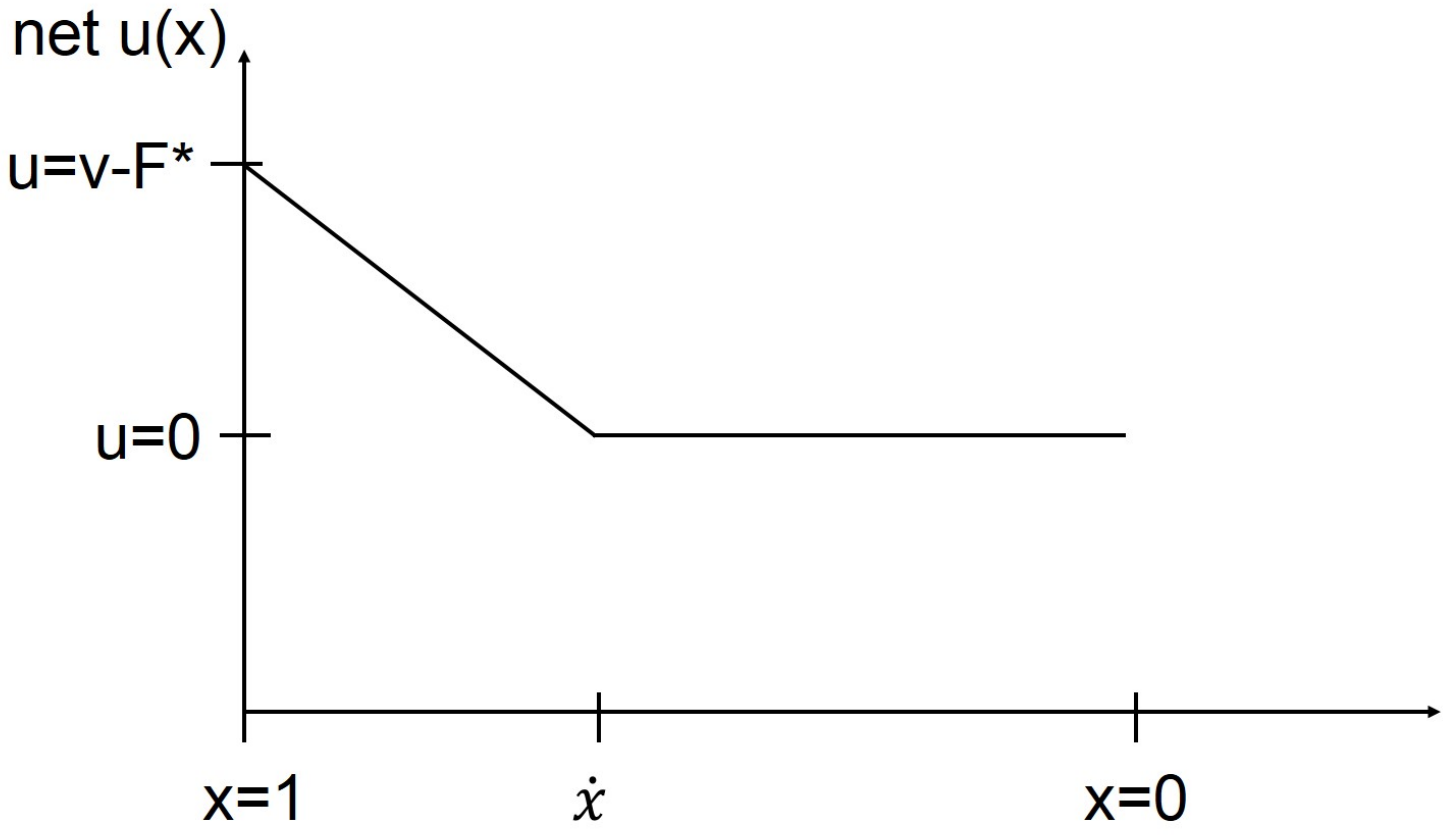
$$\bar{x}(x) = \min\left(x + (v - F)/t, 1\right)$$

Consumer-specific recommendations



Surplus extraction via biased recommendations

The platform sets the largest bias that allows consumer participation.



Exclusion of costly users

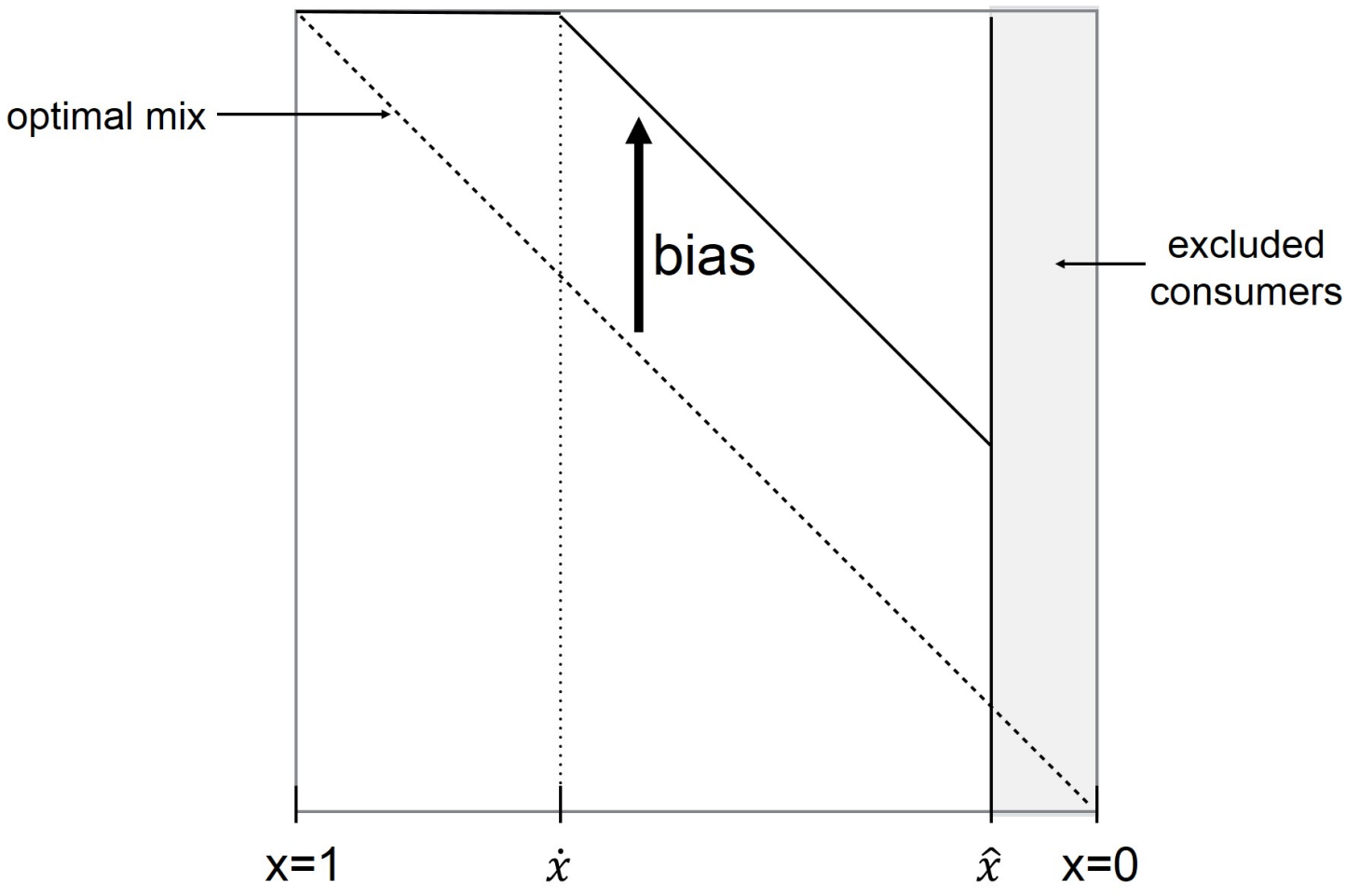
Given the optimal recommendation algorithm $\bar{x}(x)$, the platform's margin for serving consumer x is:

$$M(\bar{x}|x) = F - r_A\bar{x}(x) - r_B(1 - \bar{x}(x))$$

$r_B \geq r_A$ and $\bar{x}(x)$ increasing in $x \implies$ margin minimum at $x = 0$

If content B is very costly, we can have $M(\bar{x}(0)|0) < 0 \rightarrow$ incentives for the platform to exclude fans of B (e.g., by giving them bad recommendations).

Exclusion of costly users



Subscription fee

Notations:

- Consumers $[0, \hat{x}]$ excluded
- Consumers $[\dot{x}, 1]$ offered a mix with only content A
- We define $\Delta_r \equiv r_B - r_A$

Assuming an interior equilibrium, the problem of the platform is:

$$\max_F \Pi = \int_{\hat{x}(F)}^{1} (F - r_A)\, dx - \Delta_r \int_{\hat{x}(F)}^{\dot{x}(F)} (1 - \bar{x}(x))\, dx.$$

Maximization gives the equilibrium fee $F^\star$ and the conditions for bias ($\dot{x}(F^\star) < 1$) and exclusion of some consumers ($\hat{x}(F^\star) > 0$) to occur.

Recommendation bias in equilibrium

Lemma

The platform biases its recommendations in favor of the cheaper content iff $\Delta_r \equiv |r_B - r_A| > t$.

The platform trades-off extraction of consumer surplus and minimization of cost of content:

- Margin with recommendation $\bar{x} \geq x$:

$$M(\bar{x}) = F - r_B + \Delta\bar{x}$$

  $\rightarrow$ marginal gain from increasing bias: $\partial M/\partial\bar{x} = \Delta_r$

- Utility of user x:

$$U(x, \bar{x}) = v - F - t(\bar{x} - x)$$

  $\rightarrow$ marginal cost from increasing bias: $\partial U/\partial\bar{x} = t$

Bias and exclusion

If $\Delta_r < t$: no bias in equilibrium for participating consumers

- If $r_B > v$, the platform uses its recommendation system strategically to exclude consumers who have a strong preference for the most costly content

If $\Delta_r \geq t$: bias in equilibrium for participating consumers

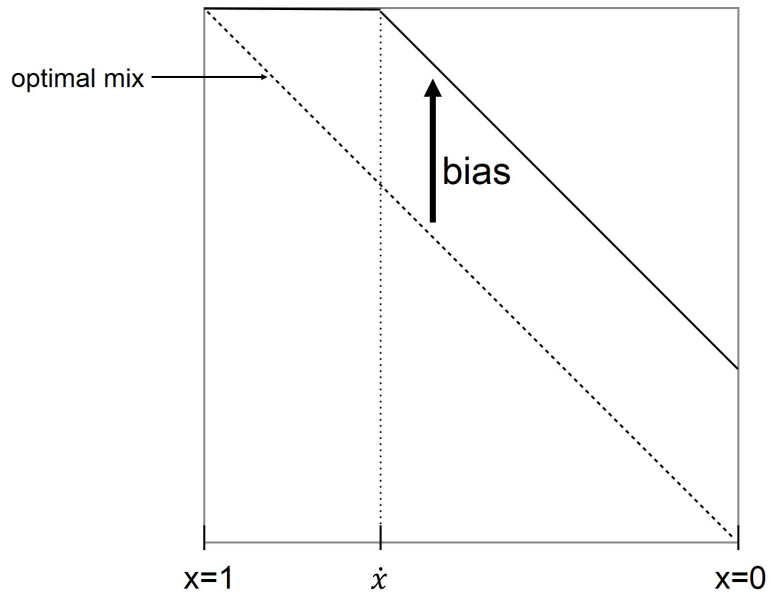
- If $v < \bar{v}(r_A, r_B) = r_A + 2t - t^2/(r_B - r_A)$, the platform excludes consumers of most costly content
- $\bar{v}$ increasing in r_A and r_B: more costly content $\rightarrow$ exclusion more likely

Personalized recommendations in equilibrium

Proposition

If $\Delta_r > t$:

- Consumers who have a strong preference for the cheaper content are subject to a full bias.
- The remaining consumers are subject to a personalized recommendation bias.



Intuition

A thought experiment, personalized subscription fees $F(x)$:

- A consumer of type x makes utility $u(\bar{x}|x) = v - F(x) - t(\bar{x} - x)$ for a mix $\bar{x} \geq x$.
- The platform then sets the maximum subscription fee such that the consumer makes positive utility, $F(x) = v - t(\bar{x} - x)$.
- It thus derives a margin $M(\bar{x}|x) = v + tx - r_B + (\Delta_r - t)\,\bar{x}$ from this consumer.

In this situation, there is **no bias** if $\Delta_r \leq t$, and **full bias** ($\bar{x} = 1$) if $\Delta_r > t$.

$\Rightarrow$ The **partial bias** in our framework (with uniform subscription fee) is a way for the platform to include marginal consumers into the market w/o lowering the fee too much for infra-marginal consumers.

Comparative statics

Proposition

For a given r_A, increasing $r_B \geq r_A$, hence Δ_r, has the following effects:

- it decreases the subscription fee for consumers (at least weakly),
- it increases consumer surplus (at least weakly),
- it decreases the platform's profit.

Small difference in royalties ($\Delta_r < t$): each consumer receives his ideal mix $\rightarrow$ homogeneous demand.

Larger difference ($\Delta_r \geq t$): recommendation bias $\rightarrow$ introduces some heterogeneity in consumer demand.

$F \downarrow$ to compensate consumers for the biased recommendations
$\Longrightarrow$ infra-marginal consumers derive a strictly positive utility

3– Endogenous royalties

Endogenous royalties

We add a first stage to the game:

- The content providers set their per-unit linear royalties r_A and r_B simultaneously.
- The rest of the game follows.

Our question: can the platform use its recommender system strategically to reduce the market power of the upstream content providers?

Extremely flexible consumers ($t = 0$)

$t = 0$: consumers have no disutility when consuming a content-mix different from their optimal mix.

The platform can extract all consumer surplus ($F = v$) while steering all of them towards the cheaper content.

$\rightarrow$ Bertrand competition between content providers.

$\{0, 0\}$ is the unique pure-strategy Nash equilibrium to the simultaneous royalty-setting game. The platform makes profit $\Pi^\star = v$.

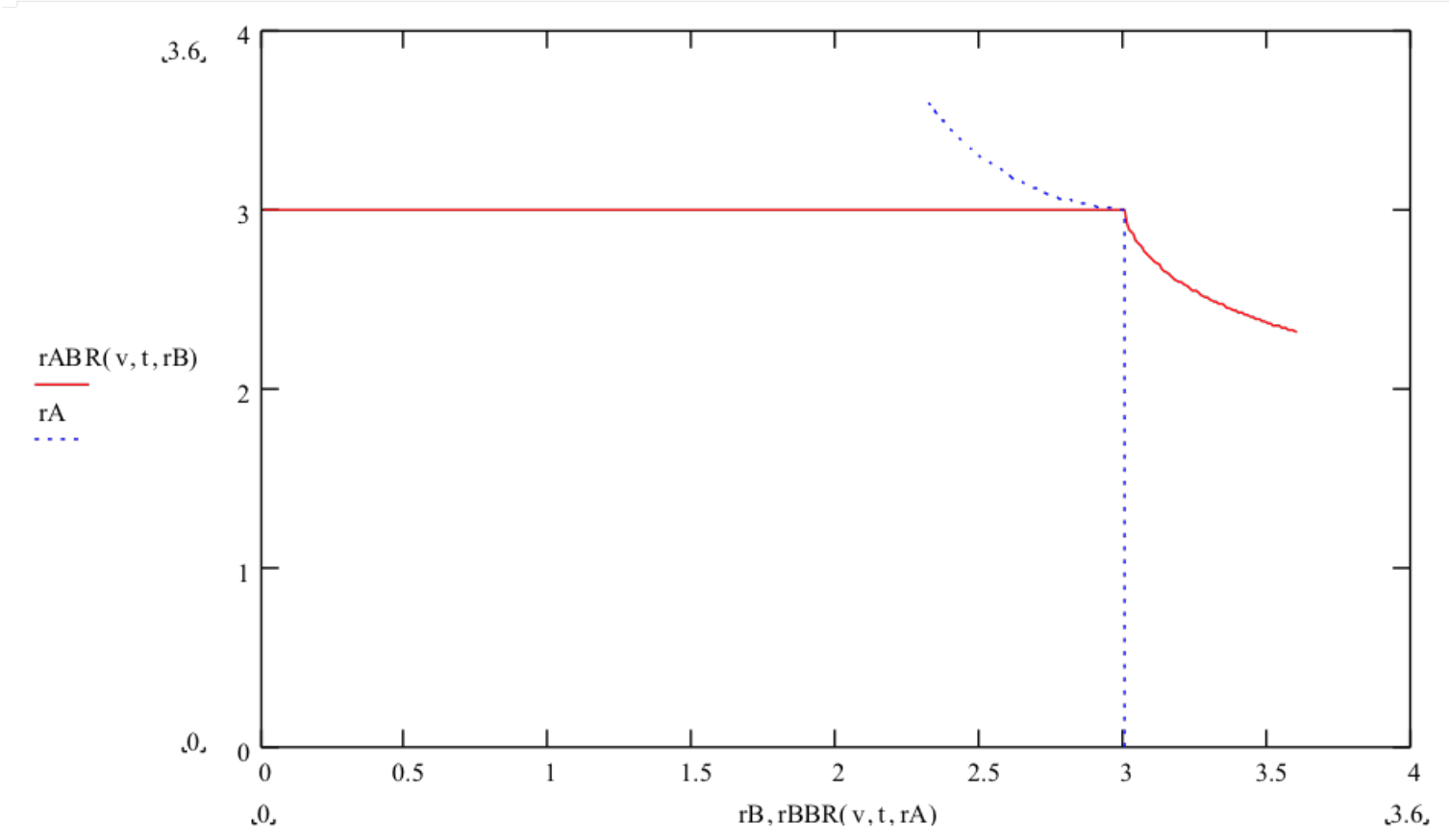
Bertrand-like equilibrium

$\{0, 0\}$ is the unique pure-strategy Nash equilibrium to the simultaneous royalty-setting game if and only if $t = 0$.

Extremely inflexible consumers ($t \to \infty$)

Unique equilibrium: $\{v, v\}$. The platform makes zero profit.

- Content A and content B "essential" for consumer participation → strong market power to content providers



Inflexible consumers (high t)

Monopoly-like equilibrium

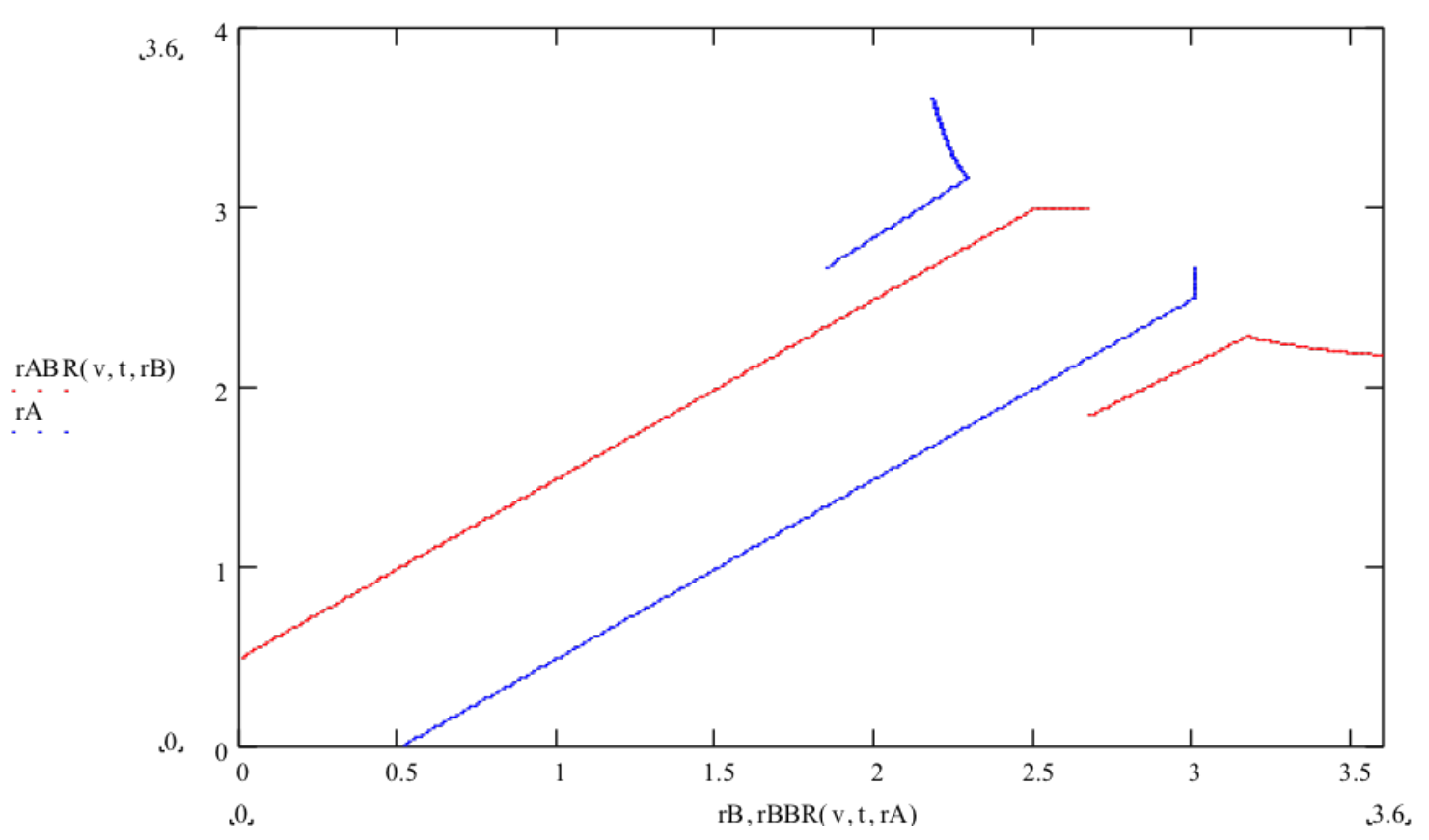
$\{v, v\}$ is the unique pure-strategy Nash equilibrium to the simultaneous royalty-setting game if $t > 2v/3$.

- There is an **equilibrium path** where, at no point on this path the platform would react to a change in input prices.
- Costly to bias $\rightarrow$ the platform prefers to absorb any price increase in royalties which is not too large rather than biasing its recommendations.
- End of path: when royalties equal v.

Flexible consumers (low t, $t \neq 0$)

No equilibrium in pure strategies

- Break in the equilibrium path.
- If B sets a very high r_B, A shifts to an interior local optimum.



4– Conclusion

Conclusion

A model of intermediary platform

- Designs a recommender system that can give rise to consumer-specific bias and exclusion via bad recommendations.
- Happens when large differences in costs of content and/or consumers don't have strong preferences for specific content.
- Equilibrium royalties give all surplus either to the content providers or to the platform.

Open questions (work in progress)

- Endogenous royalties in general case.
- Outside option: search for content?
- Impact on market structure of content market.
- Vertical integration into content market.
- "Essential" content: superstars, premium content, etc.

Thank you for your attention!