A theory of media bias and disinformation

Manuel Foerster

Bielefeld University

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Motivation

Source: Patrick LaMontagne.

- The digital revolution has fundamentally changed the way people consume news
- People today commonly get news via news websites/apps and social media platforms
  - Pew Research Center (2021)
- These developments have not only led to a fragmentation of the media landscape but also facilitated the spreading of disinformation

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  - evidence on Facebook and Twitter: Allcott and Gentzkow (2017, JEP) and Vosoughi et al. (2018, Science)
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- Rapidly advancing AI technology allowing for fabrication of image and video content like OpenAI's DALL-E exacerbates the problem
- At the same time, the digital revolution has also facilitated fact-checking, e.g., through cross-checking sources

We build a model of media bias that captures these stylized facts:

- Consumers with heterogeneous beliefs can choose between a variety of news outlets
- Biased outlets benefit politically or financially from consumers taking a certain action, e.g.,
  - (not) consuming a credence good like a medical treatment, or
  - voting for a party in line with its ideology

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- Biased outlets benefit politically or financially from consumers taking a certain action, e.g.,
  - (not) consuming a credence good like a medical treatment, or
  - voting for a party in line with its ideology
- To this end, the outlet may strategically spread disinformation, incl. the possibility of fabrication in case there is no actual news
- Consumers in turn can engage in fact-checking

The model

- Binary state of the world $\theta \in \{0, 1\}$
- Large population of consumers $N = [0, 1]$ who must each choose an action $a \in A = \{0, 1\}$
- Consumers have heterogeneous prior beliefs π on the true state being $\theta = 1$
  - continuous and strictly increasing cdf F on $[0, 1]$. This talk: F symmetric around $\frac{1}{2}$
  - identify a consumer with her prior π

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  - continuous and strictly increasing cdf F on $[0, 1]$. This talk: F symmetric around $\frac{1}{2}$
  - identify a consumer with her prior π
- At most three media firms: a neutral media firm N and two media firms L and H that are biased in opposite directions, i.e., $\mathcal{M} \subseteq \{N, L, H\}$
  - each media firm provides information via a single news outlet

Timing of events:

1. Nature draws state $\theta \in \{0, 1\}$.
2. Consumers select news outlet.
3. Firms receive private information.
4. Firms submit report to followers.
5. Followers can verify report.
6. Consumers choose action $a \in A$.
7. Payoffs realize.

Solution concept: trembling-hand perfect Bayesian equilibrium + weak form of confirmation bias (in case report does not matter for action).

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Each consumer selects which news outlet $M \in \mathcal{M}$ to follow (or subscribe to)

- media firms compete for consumers' scarce attention (relaxed in extension)

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Each media firm M

- observes the total mass of followers $F^M(1)$,
- receives the private signal $s \in \{l, h\}$ with probability $p_0 \in (0, 1)$
  - precision $p_1 = Pr(s = l|\theta = 0) = Pr(s = h|\theta = 1) > \frac{1}{2}$
  - signal s interpreted as news about θ
  - write $s = \emptyset$ if M has received no signal

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Each media firm M submits a report $\hat{s}_M \in \{\emptyset, l, h\}$ to its followers

- $\hat{s}_M = \emptyset$ interpreted as news not related to θ, e.g., trivial gossip news

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- After a follower has observed M's report $\hat{s}_M \in \{l, h\}$, she can verify it at cost $c > 0$
  - reveals true realization of s
- If a consumer π discovers that $\hat{s}_M \neq s$: M incurs reputation cost $\alpha(\hat{s}, s, \mu_\pi)$ that depends on the "size" of the lie in terms of π's posterior μ_π. This talk: $\alpha(\hat{s}_M, s, \mu_\pi) = |\mu_\pi(\hat{s}_M) - \mu_\pi(s)|$ if $\hat{s}_M \in \{l, h\} \backslash \{s\}$ and $\alpha(\hat{s}_M, s, \mu_\pi) = 0$ else.

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- Consumers: payoff 1 if $a = \theta$ and 0 else
- M's continuation payoff depends on her reputation, $\beta > 0$ measures importance
  - decreases in the share of consumers who discover a lie
- $M = N$: additional payoff from honesty
- $M \in \{L, H\}$: additional payoff from $a = 0$ and $a = 1$, respectively

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Equilibrium analysis

In a first step, we narrow down the firms' equilibrium strategies:

- For the neutral firm, truthful reporting $\hat{s}_N = s$ is a strictly dominant strategy

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- For the neutral firm, truthful reporting $\hat{s}_N = s$ is a strictly dominant strategy
- Biased firms benefit from consumers choosing a certain action and may to this end produce disinformation:

Definition: Disinformation

We refer to M's report $\hat{s}_M \in \{l, h\}$ as disinformation if $\hat{s}_M \neq s$. Furthermore, $\hat{s}_M \in \{l, h\}$

(i) distorts the private signal if $\hat{s}_M \neq s \in \{l, h\}$.

(ii) is fabricated if $s = \emptyset$.

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(ii) is fabricated if $s = \emptyset$.

- Further: M's report $\hat{s}_M = \emptyset$ suppresses the private signal if $s \in \{l, h\}$.

Lemma 1

Any equilibrium in which beliefs are monotonic is such that media firm M reports $s = h$ truthfully and either suppresses or distorts $s = l$ if $M = H$, and vice versa for $M = L$.

- $\hat{s}_H = l$ never reported because suppression induces more consumers to take its preferred action while avoiding verification

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- $\hat{s}_H = l$ never reported because suppression induces more consumers to take its preferred action while avoiding verification
- Study monotonic equilibria with the least disinformation (MELD) details
- This talk: Symmetric equilibria. We can thus represent the media firms' strategy by $q = (q_f, q_d)$
  - q_f and q_d are the probabilities of fabrication and distortion given the possibility to do so, respectively

Competition between biased firms

We first investigate competition between two biased firms, $\mathcal{M} = \{L, H\}$.

Assumption 1: $c < \frac{p_0(1-p_0)(2p_1-1)}{\max\left\{2\left(1-p_0+p_0^2p_1(1-p_1)\right),(1-p_0)^2+4p_0^2p_1(1-p_1)\right\}}$.

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- ensures that at least some consumers verify

Next, we determine consumer behavior upon observing $\hat{s}_H = h$ (analogue for $\hat{s}_L = l$).

- Verification requires that, interim, the consumer is sufficiently uncertain about her optimal action
- Since $\hat{s}_H = h$ shifts beliefs upwards, the typical consumer who verifies is (ex-ante) moderately biased toward the low action
  - verification interval $\mathcal{V}(q)$

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Example:

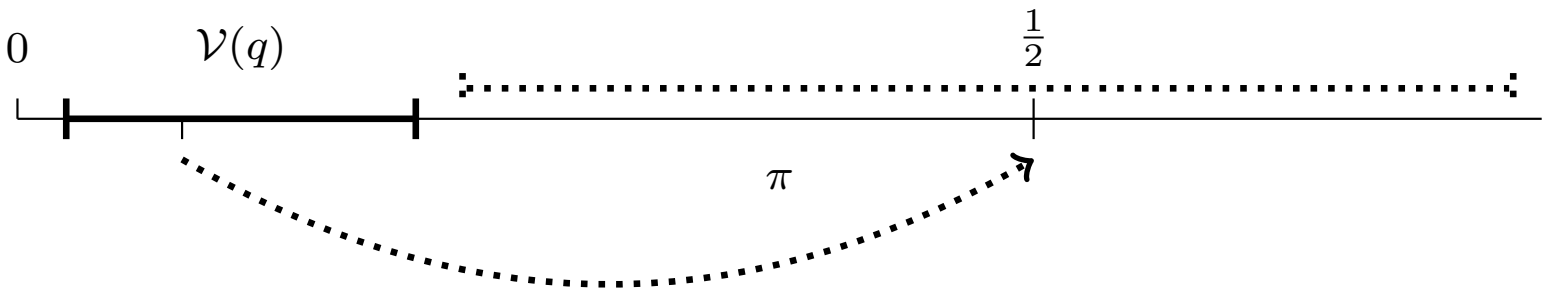

Figure: Verification interval $\mathcal{V}(q)$ and the corresponding interim beliefs after observing $\hat{s}_H = h$ (dotted line and arrow).

Proposition 1

Suppose that $\mathcal{M} = \{L, H\}$ and that F is symmetric around $\frac{1}{2}$. There exists $\underline{\beta} > 0$ such that the symmetric MELD q^* is such that

(i) $\frac{1}{2} > q_f^* > 0 = q_d^*$ and consumers $\pi \in (\underline{\mathcal{V}}(q^*), 1 - \underline{\mathcal{V}}(q^*))$ follow the outlet that is biased against their belief if $\beta \geq \underline{\beta}$,

(ii) $q_f^* = 1 \geq q_d^* > \frac{c(2-p_0)}{p_0(2p_1-1-c)}$ and consumers $\pi \in (\widetilde{\Pi}(q_d^*), 1 - \widetilde{\Pi}(q_d^*))$ follow the outlet that is biased against their belief otherwise, where $\widetilde{\Pi}(q_d^*) \geq \underline{\mathcal{V}}(q^*)$.

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- $\pi < \frac{1}{2}$: $s = h$?
- if $q_f < \frac{1}{2}$, $\hat{s}_H = h$ more informative than $\hat{s}_L = \emptyset$ on this matter
- vice versa if $q_f \geq \frac{1}{2}$

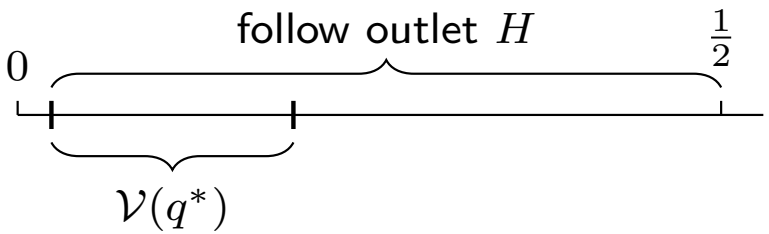

Figure: Example for Proposition 1 (i).

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Competition between neutral and biased firms

Proposition 2

Suppose that $\mathcal{M} = \{N, L, H\}$. The unique ME is such that biased firms are uninformative and any consumer

(i) $\pi \leq 1 - p_1$ follows outlet L,

(ii) $\pi \in (1 - p_1, p_1)$ follows outlet N,

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(ii) $\pi \in (1 - p_1, p_1)$ follows outlet N,

(iii) $\pi \geq p_1$ follows outlet H.

- Thus, echo chambers in which people only hear opinions similar to their own (Sunstein, 2007) arise endogenously in equilibrium
- Nevertheless, introduction of media firm N generates a Pareto-improvement for consumers

Conclusion

- We have developed a model of media bias that captures several stylized facts about today's news industry
- There is fabricated news in any equilibrium, and moderately biased consumers follow the different-minded outlet and fact-check counter-attitudinal news
  - those who, interim, are the most uncertain
- Second, our findings are in line with Sunstein (2007), who argues people sort themselves into echo chambers wherein they avoid counter-attitudinal news
  - occurs once a neutral outlet is present, but only for strongly biased consumers
- Furthermore: Comparative statics on verification costs and competition details
- In the paper: extension to multi-homing

Related literature

- Literature on media bias as distortion of private information.

  Besley and Prat (2006, AER), Gentzkow and Shapiro (2006, JPE), Denter et al. (2021, EJ)

  - Besley and Prat: "If we allowed the media to [fabricate] news, [. . .] we would need to get into a complex signalling game."
  - to our knowledge we are the first to allow for fabrication

- Literature on competition between strategic news outlets.

  Chen and Suen (2019, AEJ:Micro), Richardson and Stähler (2021), Innocenti (2021)

  - Innocenti: information design, endogenous formation of echo chambers
  - Richardson and Stähler: price competition between media firm and two fake-news providers, consumers with extreme beliefs choose to consume fake news to have prior beliefs confirmed
  - our model: echo-chamber effect arises endogenously once there is also a neutral firm, but only for strongly biased consumers

Thank you for your attention!

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Details on the model: Payoffs

- Consumer π: action $a_\pi \in A$ yields payoff 1 if $a_\pi = \theta$ and 0 otherwise
- M receives a continuation payoff of

$$\beta \left(F^M(1) - \int_0^1 v_\pi \alpha(\hat{s}_M, s, \mu_\pi) dF^M(\pi) \right), \text{ where } \beta > 0$$

  - $v_\pi \in \{0, 1\}$ verification decision of consumer π
  - may represent future revenue from advertising or subscriptions
- $M = N$: additional payoff normalized to 1 from reporting truthfully, $\hat{s}_N = s$
- $M \in \{L, H\}$: additional payoff normalized to

$$\int_0^1 a_\pi + \mathbf{1}_{\{M=L\}}(1 - 2a_\pi) dF(\pi)$$

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Details on the model: Solution concept

- Solution concept: trembling-hand perfect Bayesian equilibrium
  - simplifies the analysis: since F is strictly increasing, expected distribution of beliefs among each firm's followers strictly increasing if consumers employ completely mixed strategies
- We further incorporate a weak form of confirmation bias:

  A consumer π whose actions are affected by neither media firm chooses as to maximize the share of news that confirm her prior π, i.e., the share of high (low) messages if $\pi \geq (<) \frac{1}{2}$.

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Monotonic equilibria with the least disinformation (MELD)

Monotonic equilibrium:

- We implicitly impose the common understanding that message $\hat{s}$ means '$s = \hat{s}$'
  - "exogenous meaning", cf. Gordon et al. (2022)
- Therefore, it is natural to require that beliefs are monotonic, i.e., that $\mu_\pi(\hat{s}_M = h) > \mu_\pi(\hat{s}_M = \emptyset) > \mu_\pi(\hat{s}_M = l)$ for all $\pi \in (0,1)$ and $M \in \mathcal{M}$

Measure of disinformation:

- A monotonic equilibrium $q^* = (q_f^*, q_d^*)$ has the least disinformation if $q_f^* \leq q_f'$ and $q_d^* \leq q_d'$ for any other monotonic equilibrium q'

back

Details verification intervals

Under the biased firms' strategy q, consumers with prior $\pi \in \mathcal{V}(q)$ (and who follow outlet H) verify $\hat{s}_H = h$, where

$$\underline{\mathcal{V}}(q) = \frac{c\lambda\left((1-p_0)q_f + p_0 p_1 q_d\right) + (1+c)p_0(1-p_1)}{p_0\left(1 - c(2p_1-1)(1-\lambda q_d)\right)},$$

$$\overline{\mathcal{V}}(q) = \begin{cases} \frac{((1-p_0)q_f + p_0 p_1 q_d)\lambda(1-c) - cp_0(1-p_1)}{\lambda(2(1-p_0)q_f + p_0 q_d) + cp_0(2p_1-1)(1-\lambda q_d)}, & \text{if } q_d \leq \frac{c(2\lambda(1-p_0)q_f + p_0)}{\lambda p_0(2p_1-1-c)} \\ \frac{\lambda p_0 p_1 q_d(1-c) - c(\lambda(1-p_0)q_f + p_0(1-p_1))}{\lambda p_0 q_d + cp_0(2p_1-1)(1-\lambda q_d)}, & \text{otherwise} \end{cases}.$$

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- $\overline{\mathcal{V}}(q) > \frac{1}{2}$ iff $q_d > \frac{c(2\lambda(1-p_0)q_f + p_0)}{\lambda p_0(2p_1-1-c)}$
  - consumers biased toward action 1 may also verify $\hat{s}_H = h$ if enough distortion
- consumers with prior above $\overline{\mathcal{V}}(q)$ take action 1 upon receiving $\hat{s}_H = h$

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- consumers with prior above $\overline{\mathcal{V}}(q)$ take action 1 upon receiving $\hat{s}_H = h$
- The respective terms for firm L obtain by reflection at $\frac{1}{2}$: consumers with prior $\pi \in \mathcal{V}^*(q) \equiv \left(1 - \overline{\mathcal{V}}(q), 1 - \underline{\mathcal{V}}(q)\right)$ verify $\hat{s}_L = l$

back

Details Proposition 1

Note that consumers $\pi \in \mathcal{V}(q)$ verify $\hat{s}_H = h$ and consumers $\pi \in \mathcal{V}^*(q)$ verify $\hat{s}_L = l$. details

Proposition 1

Suppose that $\mathcal{M} = \{L, H\}$ and that F is symmetric around $\frac{1}{2}$. There exists $\underline{\beta} > 0$ such that the symmetric MELD q^* is such that

(i) $\frac{1}{2} > q_f^* > 0 = q_d^*$ and consumers $\pi \in (\underline{\mathcal{V}}(q^*), \overline{\mathcal{V}}^*(q^*))$ follow the outlet that is biased against their belief if $\beta \geq \underline{\beta}$,

(ii) $q_f^* = 1 \geq q_d^* > \frac{c(2-p_0)}{p_0(2p_1-1-c)}$ and consumers $\pi \in (\widetilde{\Pi}(q_d^*), 1 - \widetilde{\Pi}(q_d^*))$ follow the outlet that is biased against their belief otherwise, where

$$\widetilde{\Pi}(q_d^*) \equiv \frac{q_d^* p_0(1-p_1) + c\big(1 - p_0 p_1 (1 - q_d^*)\big)}{p_0\left(q_d^* - c(2p_1 - 1)(1 - q_d^*)\right)} \Big(\geq \underline{\mathcal{V}}(q^*) \Big).$$

(i) $\frac{1}{2} > q_f^* > 0 = q_d^*$ and consumers $\pi \in (\underline{\mathcal{V}}(q^*), \overline{\mathcal{V}}^*(q^*))$ follow the outlet that is biased against their belief if $\beta \geq \underline{\beta}$,

- Level of fabrication low and no distortion if continuation payoff high
  - no distortion because fabrication is a smaller lie than distortion ($\Rightarrow$ lower reputational costs)
- All but extreme consumers follow outlet biased against their belief
  - if $\pi < \frac{1}{2}$, only relevant information is whether $s = h$
  - since $q_f < \frac{1}{2} \Leftrightarrow q_f < 1 - q_f$, outlet H less likely to pool $s = \emptyset$ with $s = h$ (via $\hat{s}_H = h$) than outlet L (via $\hat{s}_L = \emptyset$)
  - in turn, low level of fabrication optimal for firms

(ii) $q_f^* = 1 \geq q_d^* > \frac{c(2-p_0)}{p_0(2p_1-1-c)}$ and consumers $\pi \in (\widetilde{\Pi}(q_d^*), 1-\widetilde{\Pi}(q_d^*))$ follow the outlet that is biased against their belief otherwise, where

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- Level of fabrication and of distortion high if continuation payoff low
  - with intermediate level of disinformation, only subset of consumers who would verify counter-attitudinal reports follow outlet biased against their belief, as $\hat{s}_L = \emptyset$ then is a good indicator of $s = h$
  - firms in turn have more to gain from fabrication
  - thus, if we have such an equilibrium, then also one with low level of fabrication
  - high level of disinformation: reports rather uninformative, and verification thus attractive again

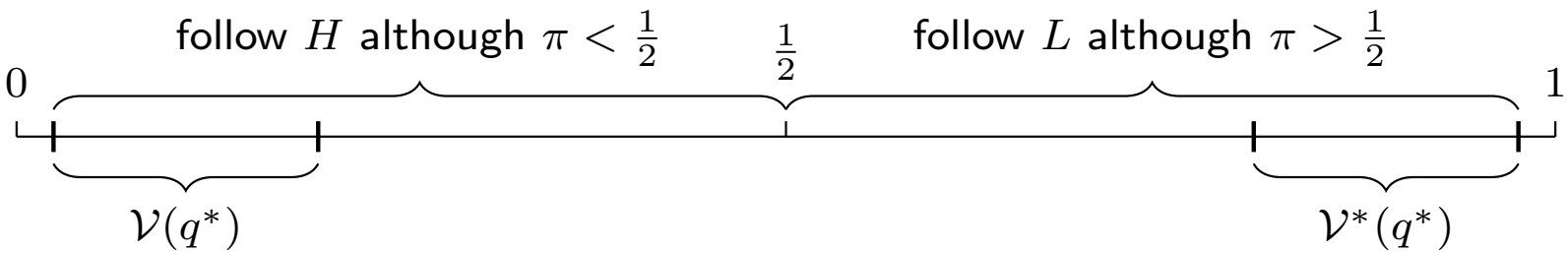
Example

Suppose that $\mathcal{M} = \{L, H\}$, $F = \mathcal{U}(0,1)$, $p_0 = \frac{1}{2}$, $p_1 = 1$, and $c = \frac{1}{5}$. The symmetric MELD q^* is such that

(i) $\frac{1}{2} > q_f^* > 0 = q_d^*$ and consumers $\pi \in (\underline{\mathcal{V}}(q^*), \overline{\mathcal{V}}^*(q^*)) = (\frac{q_f^*}{4}, 1 - \frac{q_f^*}{4})$ follow the outlet that is biased against their belief if $\beta \geq \underline{\beta} \approx 2.98$,

(ii) $q_f^* = q_d^* = 1$ and consumers $\pi \in (\underline{\mathcal{V}}(q^*), \overline{\mathcal{V}}^*(q^*)) = (\frac{2}{5}, \frac{3}{5})$ follow the outlet that is biased against their belief otherwise.

In case $\beta = 4$, this equilibrium is such that $q_f^* \approx 0.096 > 0 = q_d^*$:



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Comparative statics

Consider a monopoly model with only firm H. Since $\mathcal{V}(q)$ "shrinks" in verification costs c:

Proposition

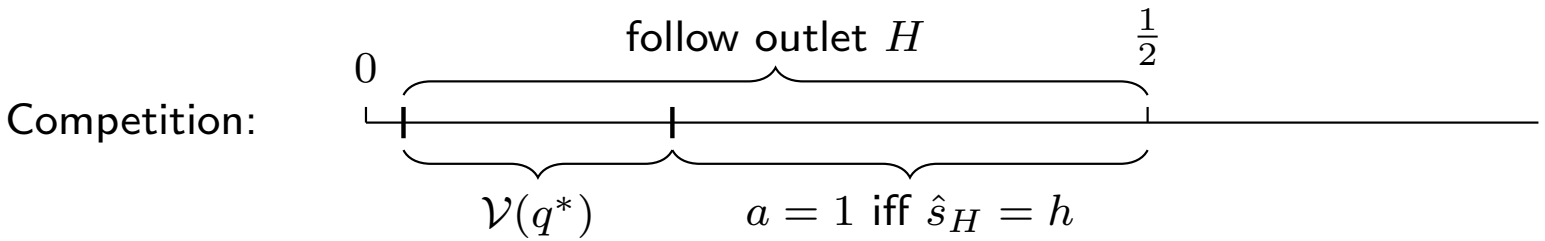
In the model with only firm H, decreasing verification costs c decreases disinformation in the MELD q^*.

- Suggests that investments in media and information literacy education may not only help those who fact-check but also result in a media environment with less disinformation

Proposition

Introducing firm L to the model with only firm H strictly reduces disinformation associated with the incumbent firm in the MELD if $\beta \geq \underline{\beta}$.

To see this, consider again the previous example:



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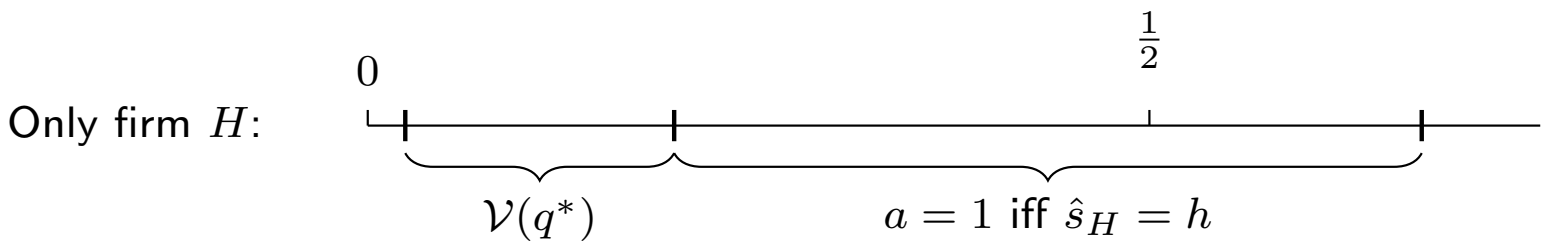
Proposition

Introducing firm L to the model with only firm H strictly reduces disinformation associated with the incumbent firm in the MELD if $\beta \geq \underline{\beta}$.

To see this, consider again the previous example:



$\Rightarrow$ More incentives to fabricate news without competition

- Thus, competition can reduce disinformation considerably

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