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Ayush Pant, Federico Trombetta

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Via Necchi 5
20123
Milano

The Newsroom Dilemma

Ayush Pant* Federico Trombetta†‡

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Abstract

Conventional wisdom suggests that competition in the modern digital environment is pushing media outlets towards early release of less accurate information. We show that this is not necessarily the case. We argue that two opposing forces determine the resolution of the speed-accuracy tradeoff: preemption and reputation. More competitive environments may be more conducive to reputation building. Therefore, it is possible to have better reporting in a more (Internet-driven) competitive world. However, we show that the audience may be worse-off due to another consequence of the Internet – outlets' better initial information. Finally, we show how a source may exploit the speed-accuracy tradeoff to get "unverified facts" out to the audience quickly.

Keywords: media competition, journalism, pre-emption, career-concern

JEL Classification Numbers: D43, D83, L82

*Department of Economics, Ashoka University. `Ayush.Pant@ashoka.edu.in`. Address: Department of Economics, Ashoka University, Plot No. 2, Rajiv Gandhi Education City, National Capital Region P.O.Rai, Sonepat Haryana-131029 (India).

†DISEIS, Università Cattlica del Sacro Cuore. `federico.trombetta@unicatt.it`. Address: Largo Gemelli 1, 20123 Milano (Italy).

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1 Introduction

On April 18, 2013, the *New York Post* plastered its cover page with a picture of two men under the headline "BAG MEN: Feds seek these two pictured at Boston Marathon." The Post was hinting that the duo was responsible for the Boston Marathon bombings and had carried the bombs in their bags. They were innocent, and the Post was wrong. 16-year-old Salaheddin Barhoum and 24-year-old Yassine Zaimi later filed a lawsuit, and the New York Post's credibility was damaged. Similarly, in September 2008, *Bloomberg* incorrectly reported that United Airlines was filing for bankruptcy. Before Bloomberg issuing a correction, United Airlines' stock price nosedived 75 percent.

Media critics often cite such examples to argue that competitive pressures in the modern digital environment have pushed outlets towards early release of less accurate information (Cairncross, 2019).[1] Matt Murray, Editor-in-Chief of the *Wall Street Journal*, acknowledged in a recent interview that the Internet had created both time and competitive pressures. However, part of the pressure, he noted, "is to stay true to what has worked and works (really) well, which is reporting verified facts." In a similar vein, some media scholars argue that the fears surrounding the effect of competition may be overblown (Knobel, 2018; Carson, 2019).

In this paper, we discuss why competition among media outlets might not privilege speed over accuracy. We consider the implications of competition on audience welfare and information dissemination. We argue that two opposing forces determine the resolution of the speed-accuracy tradeoff: preemption and reputation. While preemption pushes outlets towards speed, reputation gives media outlets a reason to engage in careful, detailed reporting.

We build a two-period model in which two career-concerned media outlets compete against one another and fear preemption. There is a topic on which the outlets may publish stories. Both outlets receive an initial informative signal about the topic. They may research the topic further at a cost, which depends upon their ability. We model research as generating a perfectly-informative signal about the topic. There is a scoop value associated with being the first outlet to publish a story on the topic. In addition to valuing scoops, outlets also care about their reputations. Reputation depends upon an audience's inference about the outlet's ability to research.

Our model yields three main results. The first two speak to the changes in the media landscape brought about by the Internet. The last result deals with how a source disseminates information to

[1]This, of course, is a cause of concern for modern democracies. Media outlets, through fact-checking and investigative journalism, deliver revelations that have a profound impact on the society and its institutions. For instance, *The Hindu*'s Bofors scam exposé in India in 1987 brought the topic of political corruption to center stage and lead to the defeat of the government in power in 1989. More recently, the *New York Times*' exposé on sexual abuse in Hollywood and corporate America has reignited discussions on gender discrimination in the workplace.

media outlets facing the speed-accuracy tradeoff.

Effect of the Internet. One effect of the Internet has been to increase competitive pressures. The Internet has reduced barriers to entry and contributed to a 24-hour news cycle where reporters are always on deadline. Consequently, pressure on media outlets to be the first to publish have increased.

In our model, while competition can push media outlets to publish more quickly, it can also have the opposite effect – to push outlets to research stories more thoroughly. We find that in more competitive environments, it is easier for outlets to build reputation. This effect increases outlets' willingness to hold back on stories and research them thoroughly. Importantly, our argument relies upon the assumption that the audience does not observe the amount of time outlets spend researching stories but they do observe which outlet publishes first. Knowing the sequence of publication rather than the amount of research, allows for additional observational learning with competition. Consequently, it gives better outlets a reason to differentiate when facing competition.

We show that when there is a high scoop value, competition drives media outlets to publish more quickly; in contrast, when there is a low scoop value, competition drives media outlets to research stories more. Therefore, the model suggests that breaking news-type stories such as those on terrorist attacks, malfeasance of senior government officials or adverse economic shocks, will suffer particularly from problems of accuracy in the Internet age. In contrast, outlets do better research on non-urgent stories that do not influence immediate decision-making. Examples include: revelations of sexual abuse by Hollywood executives, how terrorist organizations work, and illegal data hacking that is used to influence public opinion.[2]

A second effect of the Internet has been to improve what quickly-released stories look like. Journalists can quickly "contact people, access government records, file Freedom of Information Act requests, and do searches" (Knobel, 2018). Similarly, Chan (2014) argues that "digitization brings better access to sources and data." At the same time, however, the cost of doing in-depth research has not changed much. For instance, one would not expect the cost of conducting interviews and building trustworthy sources to have changed significantly. We model such an effect as improving the quality of the initial signal without changing the cost of research.

We find that a *better* initial signal can *reduce* the welfare of the audience. When initial signal becomes better, the audience is less able to attribute correct information by the media outlets to their

[2]The first story was publishished in both the *New York Times* and the *New Yorker*. https://www.newyorker.com/news/news-desk/from-aggressive-overtures-to-sexual-assault-harvey-weinsteins-accusers-tell-their-stories. The second story appeared on the *New York Times* after the reporters researched for more than a year and a half. https://www.nytimes.com/interactive/2018/04/04/world/middleeast/isis-documents-mosul-iraq.html. The third story broke out in *The Guardian.* https://www.theguardian.com/us-news/2015/dec/11/senator-ted-cruz-president-campaign-facebook-user-data.

ability to conduct in-depth research. The audience instead assign it to better initial signal of the outlets that is due to better technology. Thus, reputational concerns get diluted and timing pressures become more salient, making the media outlets move towards speed. Moving towards speed reduces overall welfare only if a significant proportion of audience values better reporting. However, it improves welfare if the audience does value early reporting. It is easy to map the above examples from the previous paragraphs to the relevant situation for audience welfare.

Information dissemination by a source. Our model is also useful for determining how a strategic source shares its information with competing media outlets. Notably, it helps explain why politically-motivated sources may share rumours with multiple outlets to get "unverified facts" out to the audience.

Our model predicts that a source who is merely interested in getting potentially incorrect information out without further research can exploit the time pressures that competing media outlets face. We show that when media outlets are intrinsically driven to explore issues, it is better to share information with all the media outlets to get the information out quickly. More intrinsically motivated media outlets are more likely to do further research independent of the competition. However, by sharing with all the media outlets and creating competitive pressures, additional time pressure can be created. Thus, politicians with propaganda may still hold media outlets hostage even without explicitly capturing or buying them off.

It is worth emphasizing that our model generally covers settings that have elements of preemption and career concerns. For instance, competing researchers working to solve similar problems and hoping to convince a market about their ability face a similar newsroom dilemma. Technology firms face a speed-accuracy tradeoff as they build products and technology to match consumer preferences. Our main results have a natural interpretation in these situations. Notably, better research in competitive environments requires that the initial research idea is not too well-developed.

Contributions to related literature. The speed-accuracy tradeoff is commonly recognized in the media studies literature.[3] The literature highlights two critical determinants of the rise of "speed-driven journalism" in the modern digital environment. The first one is increasing competitive pressure. Rosenberg and Feldman (2008), for instance, highlight that journalists "telecast unscreened material" to "beat the competition." The second is the 24-hour news cycle (Lee, 2014; Starbird, Dailey, Mohamed, Lee, and Spiro, 2018), which leads to the possibility of being preempted at any point in time.[4]

[3]The BBC Academy website observes that "every journalist has to resolve the conflicting demands of speed and accuracy. [...] If you are working on a breaking news story, it is important to remember that first reports may often be confused and misleading. [...] That is why it is important to weight the facts you have."

[4]As Howard Kurtz from *Washington Post* describes, "In the last year, the pendulum has swung in our newsroom to putting things on the Web almost immediately [...] everybody wants it now-now-now. [...] But the sacrifice (clearly) is in the extra phone calls and the chance to briefly reflect on the story that you are slapping together"

Importantly, however, reputational concerns remain relevant. *Reuters Handbook of Journalism* states, "Reuters aims to report facts, not rumors. Clients rely on us to differentiate between fact and rumor, and our reputation rests partly on that." Note that reputation is based on the ability to check the facts before releasing them, which is also how we model it. Knobel (2018) summarizes her interviews with the editors by saying that they realize that readers can be induced to pay for quality journalism.[5] The model we build tries to combine these insights into a unified analysis of the speed-accuracy tradeoff and the competing forces that determine its direction.

The newsroom dilemma, however, is surprisingly understudied in media economics despite agreement among media scholars on its importance. We primarily contribute by explicitly modeling the newsroom dilemma and determining its effect on the quality of news.[6]

Our paper relates to some new literature that explores, theoretically and empirically, the effect of the Internet (or more generically of new technologies) on the media landscape. Cagé, Hervé, and Viaud (2019) stress on the commercial value of building a reputation for original content in the internet era when there is widespread use of copy and paste between news outlets. In Angelucci and Cagé (2019) the authors show that a drop in the advertising revenues due to television entry in France leads to a smaller newsroom, decrease in prices and a move towards "soft" information. Angelucci, Cagé, and Sinkinson (2020) show that television entry in the US reduced readership, advertisement and original reporting of newspapers. Armstrong (2005) looks at the relative effect of advertising-only with a subscription-based funding mechanism on journalistic quality. Most of these papers and others (Ellman and Germano, 2009; Gentzkow, 2014) build on two-sided market models (Rochet and Tirole, 2003, 2006) and are concerned with pricing decisions, rather than with the speed-accuracy trade off. We do not explicitly model advertising and pricing concerns. We instead subsume them under either preemption or reputational concerns.[7]

Focusing more on the reputation-building and signaling in media markets, Gentzkow and Shapiro (2006) model media bias and reputation building, showing that competition reduces bias. The model explores an entirely different tradeoff looking at the content of the reporting directly, rather than the timing. Gentzkow and Shapiro (2008) later provide an outline of a model that may incorporate

[5]She quotes Rex Smith, editor of the *Albany Times Union*, "What can separate great journalism from everything else is our commitment to the journalism of verification and watchdog reporting. It will give us credibility that other organizations do not have." See Appendix E for a summary of Knobel (2018)'s results and how it relates to our findings.

[6]One exception is Andreottola and De Moragas (2017). They look at the political economy impact of a similar speed-accuracy tradeoff and find that competition leads to a release of less accurate information. Our paper differs because we explicitly model the reputational concerns of media outlets. We identify conditions where the additional information transmitted by the presence of competitors overcomes the preemption concerns.

[7]Some recent papers that do not look at pricing explicitly but explore the political consequences of new media or of media competition are Sobbrio (2014), Cagé (2019), Allcott and Gentzkow (2017), Barrera, Guriev, Henry, and Zhuravskaya (2017), Chen and Suen (2016), Perego and Yuksel (2018) and Vaccari (2018). In all these papers, there is no speed-accuracy tradeoff.

reputation-building incentives like ours but they do not consider preemption. Shapiro (2016) shows that reputational concern for unbiasedness may induce journalists to report evidence as ambiguous even when it is not. Preemption concerns and endogenous choice of research are not considered there.[8]

We also contribute to the literature on strategic information release. We differentiate from Guttman (2010) and Guttman, Kremer, and Skrzypacz (2014) by adding reputational concerns and endogenizing the information acquisition choice. Therefore, our results are driven by completely different incentives. Relatedly, Aghamolla (2016) looks at a model of (anti-)herding between financial analysts with observational learning and endogenous information acquisition. Observational learning is relevant only for the audience in our model because it signals the type of the outlet. Gratton, Holden, and Kolotilin (2017) look at a model in which a sender strategically releases a stream of information to influence perceptions about herself. They show that better sender types release the information earlier and expose themselves to scrutiny. This is in contrast with our model, where better outlets release information later. In our model, outlets who give information later are conferred reputational benefits due to preemption concerns, which arises due to competition. In their model, there is no competition and senders build reputation by opening themselves to more scrutiny by early release of information.

Finally, we also contribute to the literature on preemption games and R&D races by adding reputational concerns. Preemption games have long been studied in economics (Fudenberg, Gilbert, Stiglitz, and Tirole, 1983; Fudenberg and Tirole, 1985), but our paper contributes to the more recent literature on preemption games with private information (Hopenhayn and Squintani, 2011, 2015; Bobtcheff, Bolte, and Mariotti, 2016). It is worth noting that Bobtcheff et al. (2016) have a similar "separating" result for different types of firms, but in a set up without reputation. Here we point out that reputation, combined with actions that partially reveal an opponent's type, can be a different force leading to separating strategies in preemption games.

2 A model of the newsroom dilemma

We build a simple two-period model indexed by $t = 1, 2$ featuring three players: two strategic media outlets i, j and a fixed mass of audiences. We also consider a version with just one media outlet.

State of the world. The state of the world ω is binary and unknown to the players. Formally, $\omega \in \Omega := \{a, b\}$ with common prior $\Pr(\omega = a) = \frac{1}{2}$. Ω pertains to the topic on which the media outlets

[8]Our modelling strategy shares some features with Hafer, Landa, and Le Bihan (2018, 2019). Like us, they have a two period model where competing outlets can acquire information about a politically relevant state of the world and choose when to release it. However, we do not focus on media bias and on the possibility of claiming credit for a story, but rather on the trade off between time pressure and quality of journalism. See Prat and Strömberg (2013) and Strömberg (2015) for recent developments in the political economy of media literature, and other related papers.

are digging a story, and the relevant information for the audience. This could be, for instance, who is responsible for a terrorist attack, whether a senior government official is involved in corruption or not, who is an appropriate candidate to vote for in the election, etc.

Media outlets. Initially, each outlet privately observes a signal s^i about the state of the world in $t = 1$. We call this the story that the outlets have. We assume that s^i is free and i.i.d. conditional on the state. Its precision is $\Pr(s = \omega|\omega) = \pi > \frac{1}{2}$. The two outlets decide simultaneously at this stage whether to publish their signals, or conduct further research. The decision d^i for outlet i in $t = 1$ is, therefore, to choose from $\{pub, res\}$ where pub is publish immediately, i.e. in $t = 1$, and res is do more research and then publish in $t = 2$.

Publishing is equivalent to endorsing a particular state of the world (independent of whether published in $t = 1$ or 2). When an outlet publishes its story it sends a message $m \in M = \{\tilde{a}, \tilde{b}\}$ where $\tilde{\omega}$ means endorsing state ω.

Conducting further research (and then publishing in $t = 2$) is costly. In particular, there is a type specific cost of research that perfectly reveals the true state of the world in $t = 2$. Outlets can be of two types, high or low quality, depending on how efficient they are at digging into stories, and this is the private information of each individual outlet. Formally, the type of outlet i is $\theta^i \in \{h, l\}$ with a common prior $\Pr(\theta^i = h) = q = \frac{1}{2}$. The types are independent.

$\theta = l$ faces an infinite cost of conducting research. The low quality outlet never digs stories further and chooses $d = pub$ in $t = 1$. The cost c for the high quality outlet is private information of that outlet, and is story-specific. It comes from a uniform distribution F with support $[-\varepsilon, \bar{c}]$ and is drawn independently for each high quality outlet. ε is greater than zero but small to capture the idea that some high quality outlets may still want to conduct research even in the absence of other rewards.[9] We assume $\bar{c} \geq 2$ so that the support of the distribution F is sufficiently large.

Finally, the assumption on q is just for analytic convenience. A generic $q \in (0, 1)$ would not alter the results, qualitatively. We show this case in Appendix C.

Audience. The audience enters the game when one or both of the outlets publish their story, and their story is revealed (i.e. m). They only rationally form beliefs about the types of the outlets. They enter with the knowledge of the priors and an understanding of the competition between the outlets. Other than this, the precise information of the audience at the time of belief formation is denoted by the set $\mathcal{I}$.

[9]Interviews with editors often confirm such motivations; often they feel a sense of responsibility in their positions. For instance, Knobel quotes Marcus Brauchli, *Washington Post*'s former editor, "Doing investigative journalism is in the *Post*'s DNA and has been as long as any of us have been around in journalism." Similarly, Kevin Riley, the Editor of the *Atlanta Journal-Constitution* explains, "People want us to do this. They don't think anyone else will if we don't."

We assume that the audience observes the sequence of publication but not the actual time of publication, or whether the outlets conducted research. The sequence, as distinguished from the timing, shows whether the outlets moved sequentially or simultaneously. Under this assumption, the audience will be able to determine the actual time of publication (i.e. $t = 1, 2$) only if the outlets moved sequentially. It can be summarized by $\tilde{t}^i \in \{\text{I}, \text{II}, \varnothing\}$, which shows whether outlet i was first, second, or it moved simultaneously with j. This assumption is discussed in more details in Section 2.2 and its implications are described in the main analysis in Section 3.

In addition, after both the outlets publish their stories, the state is revealed exogenously. If $m^i = \omega$, then outlet i is said to be right, or R. Otherwise, the outlet is wrong, denoted by W. We call this the outcome O of verification. The audience sees the outcome. Therefore, the information of the audience $\mathcal{I}$ at the end of the game is denoted by a tuple $(O^i_{\tilde{t}}, O^j_{\tilde{t}})$ that consists of four pieces of information, i.e. the position of each outlet in the sequence of publication and their outcomes. Using $\mathcal{I}$, the audience updates its beliefs about each outlet's type. Denote the posterior belief about $\theta = h$ by $\gamma(\mathcal{I})$ when the information held by the audience is $\mathcal{I}$.

Payoffs. Currently, we do not illustrate the payoffs of the audience as they only form beliefs. We will, however, place more structure on its preferences at a later stage and explain the source of outlets' payoffs. For the time being, we only focus on the outlets' payoffs, which are composed of three elements.

1. The first is a scoop value v to the first outlet publishing the story. It captures the preemptive nature of the media market, highlighted for example in Besley and Prat (2006). v can be interpreted as the mass of audience that is drawn to the first media outlet breaking the story.

2. The second is a reputation value of γ^i or the audience's posterior on the quality of outlet i calculated after revelation of the true state. This captures the extent to which the outlets care about their reputation. For instance, future audience of the outlets might depend on their reputations. We assume that reputation enters linearly in the outlets' payoffs. Importantly, the audience cares about whether the outlet is high or low type, not about c. A new c is drawn for every new story and only the high type has the ability to conduct further research.

3. The third is the cost c that the high type outlet chooses to pay if it does research in period 1.

Timing. The timing of the game can now be summarized as follows:

0. Nature draws ω, θ^i and θ^j. θ is privately observed by each outlet. ω is unobserved.

1. At $t = 1$ each outlet privately observes s^i. A cost c of digging into the story is drawn from a uniform distribution $F[-\varepsilon, \bar{c}]$ for the high type.

2. The outlets simultaneously decide $d^i \in \{pub, res\}$ and if $d^i = pub$ then also choose m. As stated before, this is a relevant decision only for the high type. The low type always chooses pub.

3. If both outlets publish, the game ends. Otherwise, the game goes to period 2.

4. At $t = 2$, the state is revealed to every outlet that chose $d^i = res$. Those who did not publish in $t = 1$, publish now by choosing m.

5. Once both the outlets have published, the state ω is revealed to the audience. They observe $\mathcal{I}$ and update beliefs on the type of each outlet. Payoffs are realized.

2.1 Solution concept and equilibria selection

The solution concept we use is the Perfect Bayesian Nash Equilibrium in pure strategies. We focus on equilibria where outlets optimally follow the signal they receive, i.e they endorse the state that is more likely to be the true one given their signal. We call such equilibria *signal-based* equilibria.[10] For the rest of the paper, we use "equilibrium" and "signal-based equilibrium" interchangeably.

2.2 Discussion of assumptions

Before proceeding to the analysis, it is worth discussing our assumptions in detail.

The first assumption we make is regarding what the audience observes about the timing of the game. The fact that the audience only observes the content of what was published (i.e, m) and the sequence of publication (i.e., $\tilde{t}$ but not the actual t) captures the idea that it is unaware of how much the outlets researched story. We believe this is a realistic assumption in that the amount of research is hardly observable from outside the newsroom. Of course, the amount of research conducted maps in a probabilistic way into the accuracy of a story, which the audience can check more easily. We allow for such a possibility by letting the audience observe whether the story is true or false.

The important consequence of this assumption is that player i's decision to publish/not publish can potentially convey information about player j's type. For example, if the two outlets move sequentially and only a high type is expected to conduct research, moving later is a signal of the first outlet being a low type. We show how relaxing this assumption changes our result in Section 3.4.

The second assumption we make is about who possesses stories on a topic. In reality, competing media outlets are often unaware of whether their competitors are also exploring the same story. We

[10] This means that we ignore equilibria where outlets choose to endorse one particular state to signal their type. Those equilibria may exist, but we argue that they do not make much sense given the environment we are considering. Alternatively, we can assume that signals are hard information, but the reader cannot infer the level of precision: the result would be exactly the same.

assume that both of the media outlets are aware that their competitor also possesses the story. Doing so pushes the incentives of the outlets the most towards speed. Still, we show that more research is possible under competition. Including such a possibility further adds to the complications of the model.

The third assumption we make is that outlets build a reputation on their consistent types, and not on the cost of digging into each independent story. Given that different outlets usually have different expertise, it is reasonable to assume that they face different costs when exploring different stories. For instance, *The Wall Street Journal* is a business-centric daily and has invested in building sources and methods for dealing with business stories (such as avoiding lawsuits when potentially sensitive corporate information is published). However, in general, some outlets have a culture of researching while others do not. Their type captures this.

We also make a few assumptions for tractability reasons. First, we do not allow for the outlets to "sit on information" or wait for a period before publishing.[11] Second, we assume that the audience correctly finds out the state at the end of the game. Third, we assume that the media outlet correctly finds out the state upon choosing to research. Almost all of these assumptions can be relaxed to some degree without altering our predictions.

Finally, it is worth emphasizing that there is an informational value of the news to the audience in our model. They want to know the actual state, which allows them to make decisions or form opinions. Our model, therefore, does not deal with the entertainment value of news where the audience enjoys getting the information.

2.3 Preliminary observations and strategies

We start with a few simplifying observations. All the proofs are in Appendix A.

Observation 1 *Suppose there are reputational gains in matching the state. If an outlet decides to publish in $t = 1$, it follows its signal s, i.e sends $m = s$. If an outlet decides to do research and then publish in $t = 2$, it follows the outcome of research.*

Observation 1 follows from the fact that in $t = 1$ the most informative signal is s. Therefore, the most likely state is the one given by the signal. This is a standard result in this type of environment and follows from the flat priors on the state. Moreover, in $t = 2$ the outlet choosing to research has learned the actual state and therefore, publishes it (independent of what the original signal s stated). Thus, as long as there is a gain in matching the state, each outlet follows its last signal, which is also the most informative one.

[11] We can show that for a sufficiently high v and relevant off-path beliefs, the outlets never choose to wait.

There is also a useful result arising from our particular signal structure and flat prior over the state.

Lemma 1 *If each outlet follows its last signal when publishing, the following results hold:*

1. *The probability of matching the state after only s is π.*

2. *Regardless of whether i decides to publish or research, from its point of view the expected probability of player j matching the state without research is π.*

Lemma 1 will be helpful in writing the incentive compatibility conditions for the players. Doing so will require each outlet to consider whether the other will do research and the subsequent probability of matching the state.

It is useful to define precisely the strategies we will focus our attention on. Note first that the only relevant and meaningful decision that deserves our attention is the one of the high type outlet in period 1. From the the outlet's point of view, this will be a threshold strategy where the threshold is defined on the cost c of research. The high outlet conducts research if the realized cost c is less than some threshold c_D (where subscript D represents the case of a two firm duopoly).[12] From the other outlet's (and the audience's) point of view, define σ^i, the conjectured probability that outlet i chooses to research further in $t = 1$, conditional on outlet i being a high type. Therefore,

$$\sigma^i = \Pr(c \leq c_D) = F(c_D) = \begin{cases} 0 & c_D < -\varepsilon \\ \frac{c_D+\varepsilon}{\bar{c}+\varepsilon} & -\varepsilon \leq c_D \leq \bar{c} \\ 1 & c_D > \bar{c} \end{cases}$$

We are now ready to move to the equilibrium analysis arising in different market configurations.

3 Competition leads to better reporting

3.1 Newsroom dilemma with a single firm: Monopoly

Let us start with the simplest case: there is a single media outlet and its type is known to the audience.

Proposition 1 *If there is one media outlet and θ is known to the audience, then the high quality outlet conducts research with probability $F(0) = \frac{\varepsilon}{\bar{c}+\varepsilon}$.*

[12] Similarly, the case of single firm monopoly is denoted by a threshold c_M and in general, by a subscript M.

In this case, none of the aforementioned incentives are at play. There is obviously no preemption risk and there is nothing to do in terms of reputation. Every type of outlet gets $v + \mathbb{1}\{\theta = h\}$ so it is pointless to pay any cost for researching. The outlet is driven to research only because of its intrinsic motivation.

The case of monopoly with unknown type is more interesting. Suppose that the high outlet is expected to choose to research with probability σ. As the preemption risk is absent in this case with only one outlet, v does not play any role. However, a high outlet has an incentive to do research to build a reputation for being a high quality. But note that this reputation cannot be based on the observation of sequence or timing. The only relevant thing that the audience observes is whether the outlet is right (R) or wrong (W), i.e. whether $m = \omega$ or not after the state is verified. Therefore, the two relevant belief updates are

$$\gamma(R;\sigma) = \frac{\sigma + (1-\sigma)\pi}{\sigma + (1-\sigma)\pi + \pi} \text{ and } \gamma(W;\sigma) = \frac{(1-\sigma)(1-\pi)}{(1-\sigma)(1-\pi) + (1-\pi)} = \frac{1-\sigma}{2-\sigma}$$

from Bayes' rule.

Notice that $\gamma(.)$ is a function of σ, or the expected probability of research. As a result, a high outlet does research if

$$\overbrace{\gamma(R;\sigma) - c}^{\text{expected payoff from research}} \geq \underbrace{\pi\gamma(R;\sigma) + (1-\pi)\gamma(W;\sigma))}_{\text{expected payoff from publication}} \implies c \leq (1-\pi)(\gamma(R;\sigma) - \gamma(W;\sigma)) := c_M(\sigma)$$

where the equilibrium cost threshold $c_M(.)$ is a function of the conjectured σ. Therefore, the equilibrium σ, σ^*, is the solution to the fixed point equation $\sigma^* = F(c_M(\sigma^*)) = \frac{c_M(\sigma^*)+\varepsilon}{\bar{c}+\varepsilon}$. Proposition 2 below shows that such a fixed point exists and is unique.

Proposition 2 *If there is one media outlet and θ is not known to the audience, there exists a unique equilibrium in which the high quality outlet conducts research in $t = 1$ iff*

$$c \leq (1-\pi)(\gamma(R;\sigma^*) - \gamma(W;\sigma^*)) := c_M(\sigma^*).$$

As a consequence, $\sigma^* = F(c_M(\sigma^*)) = \frac{c_M(\sigma^*)+\varepsilon}{\bar{c}+\varepsilon}$.[13]

Proposition 2 captures the idea that c_M is defined so that the additional cost c of choosing $d = res$ is more than compensated by the expected reputational gains from endorsing the correct state. Notably,

[13] In the proofs, we drop σ from $\gamma(.)$ and write it only as $\gamma(R)$ and $\gamma(W)$. This is done for easing the mathematical notation.

the reputational gains arise for the high outlet only in the event that doing research helps match the state. Since this was already happening with probability π by not researching, the additional benefits of doing research occur with probability $1-\pi$.

3.2 Newsroom dilemma with two firms: Duopoly

The main effect of competition is the introduction of preemption risk. When preemption is relevant and reputation building is not, then the equilibrium where the high quality outlet conducts research becomes even rarer than in Proposition 1. Proposition 3 below highlights this.

Proposition 3 *If there are two media outlets and θ is known to the audience, there exists a unique symmetric equilibrium in which the high quality outlets conduct research with probability $\sigma_D^* = F\left(-\frac{v}{2}\right)$.*

Intuitively, there is nothing to gain from conducting research in terms of reputation as θ is known. The only reason to investigate further is if there is an intrinsic motivation to do so. But now there is a preemption risk that reduces the incentives to investigate. However, if v is sufficiently small relative to the intrinsic motivation (i.e. if $v < 2\varepsilon$), there will still be some high outlets willing to investigate.

The case of competition plus hidden types is the most interesting one. In this case, both the preemption and reputation building concerns are simultaneously relevant and interact with each other. Before we present the key proposition, we discuss how the audience updates beliefs in this environment. Recall that the audience observes both the outcome of verification $\mathcal{O} \in \{R, W\}$ and the sequence of publication $\tilde{t} \in \{\text{I}, \text{II}, \varnothing\}$ for both i and j. Suppose now that a high quality outlet chooses to research with probability σ^i. Then, for a given conjectured level of σ^i and σ^j, the relevant audience's on-path beliefs need to be defined for the following events:

$$\{(R_\varnothing, R_\varnothing), (R_\varnothing, W_\varnothing), (W_\varnothing, W_\varnothing), (W_\varnothing, R_\varnothing), (R_\text{I}, R_\text{II}), (W_\text{I}, R_\text{II}), (R_\text{II}, R_\text{I}), (R_\text{II}, W_\text{I})\}$$

where the first outcome-sequence element in each information set is outlet i's and the second is outlet j's.[14]

It can be shown that there are three relevant set of events for belief updating. The first is when both the outlets get the state correct and they publish simultaneously.

$$\gamma^i(R_\varnothing, R_\varnothing) = \frac{\sigma^i\sigma^j + (1-\sigma^i)(2-\sigma^j)\pi^2}{\sigma^i\sigma^j + (2-\sigma^i)(2-\sigma^j)\pi^2} := \gamma^i(\varnothing; \sigma_i, \sigma_j)$$

[14]Note that it never happens that an outlet moves second in the sequence and gets the state incorrect. Any outlet that moves second has conducted research and matches the state perfectly. Therefore, any event with W_II does not occur on-path.

Here the audience is unable to determine the actual timing of publication. It cannot distinguish as to whether both conducted research (which happens only if both are high types) or both published immediately (either because they are both low types, or because there is only one high type and it faced a high cost, or because both are high types but they faced high costs). With some abuse of notation, we denote the updated belief under "no information about timing" event by $\gamma(\varnothing; \sigma_i, \sigma_j)$.

The second is when the audience is able to determine that outlet i moved in $t = 1$.

$$\gamma^i(R_\varnothing, W_\varnothing) = \gamma^i(W_\varnothing, W_\varnothing) = \gamma^i(W_\varnothing, R_\varnothing) = \gamma^i(R_{\text{I}}, R_{\text{II}}) = \gamma^i(W_{\text{I}}, R_{\text{II}}) = \frac{1-\sigma^i}{2-\sigma^i} := \gamma^i(1; \sigma_i)$$

This, of course happens when i moves first and j moves second (independent of whether i gets the state correct or not). But the audience is also able to understand it when the outlets move simultaneously and at least one of them gets the state incorrect (since researching further perfectly reveals the state). Here the only uncertainty for the audience is whether the outlet is a high quality one that faced a high cost or a low quality one. We denote the updated belief under the "published in period 1" event by $\gamma(1; \sigma_i)$. Observe how in these events the presence of a competitor conveys to the reader some additional information about the type of each outlet.

Finally, the third is when the audience is able to determine that outlet i moved in $t = 2$.

$$\gamma^i(R_{\text{II}}, R_{\text{I}}) = \gamma^i(R_{\text{II}}, W_{\text{I}}) = 1 := \gamma^i(2)$$

This only happens when outlet i moves second and gets the state correct, which in turn is only possible if it is a high quality outlet. Therefore, the updated belief under "published in $t = 2$" event is $\gamma(2) = 1$.[15]

Using these updated beliefs, a high quality outlet's incentive compatibility can be written as follows. For any given conjectured σ^j and audience's beliefs, a high quality outlet i with cost c^i chooses to research further if

$$\overbrace{\frac{1}{2}\left[\sigma^j\left(\frac{v}{2} + \gamma^i(\varnothing; \sigma_i, \sigma_j)\right) + (1-\sigma^j)\gamma^i(2)\right] + \frac{1}{2}\gamma^i(2) - c^i}^{\text{expected payoff from research}} \geq$$
$$\underbrace{\frac{1}{2}\left[\sigma^j(v + \gamma^i(1, \sigma_i)) + (1-\sigma^j)\left(\frac{v}{2} + \pi^2\gamma^i(\varnothing; \sigma_i, \sigma_j) + (1-\pi^2)\gamma^i(1; \sigma_i)\right)\right] + \frac{1}{2}\left(\frac{v}{2} + \pi^2\gamma^i(\varnothing; \sigma_i, \sigma_j) + (1-\pi^2)\gamma^i(1, \sigma_i)\right)}_{\text{expected payoff from publication}}$$

[15] This is off path if, in equilibrium, every high quality outlet chooses not to research. However, we assume that off path beliefs are $\gamma(2) = 1$ in this case as well.

which further simplifies to

$$c^i \leq \frac{1}{2}\left[\left(\gamma^i(\varnothing;\sigma_i,\sigma_j)-\gamma^i(1;\sigma_i)\right)\left(\sigma^j-(2-\sigma^j)\pi^2\right)+(2-\sigma^j)\left(1-\gamma^i(1;\sigma_i)\right)\right]-\frac{1}{2}v := c^i_D(\sigma_i,\sigma_j) \quad (1)$$

As before, the cost threshold $c_D(.)$ is endogenous to the conjectured strategies σ_i and σ_j. In equilibrium, it is required that both σ_i and σ_j are solutions to the fixed point equations $\sigma_i = F(c_D(\sigma_i,\sigma_j))$ and $\sigma_j = F(c_D(\sigma_i,\sigma_j))$. Proposition 4 then follows:

Proposition 4 *If there are two media outlets and θ is not known to the audience, there exists a unique and symmetric equilibrium where $\sigma^{i*} = \sigma^{j*} := \sigma^* = F(c_D(\sigma^*))$ such that*

$$c_D(\sigma^*) = \frac{1}{2}\left[\left(\gamma(\varnothing;\sigma^*)-\gamma(1;\sigma^*)\right)\left(\sigma^*-(2-\sigma^*)\pi^2\right)+1\right]-\frac{1}{2}v$$

where $\gamma(\varnothing) = \frac{(\sigma^*)^2+(1-\sigma^*)(2-\sigma^*)\pi^2}{(\sigma^*)^2+(2-\sigma^*)^2\pi^2}$ and $\gamma(1) = \frac{1-\sigma^*}{2-\sigma^*}$.

Looking now at the cost threshold c_D of Proposition 4, we can see the negative effect of v. If preemption concerns are very salient (i.e. v is high), then separation happens for a smaller range of c making research less likely. On the other hand, the positive side of the condition is given by the expected reputational gains of matching the state (and publishing second).[16]

3.3 Competition may lead to better reporting

The comparison between monopoly and duopoly when reputation building is relevant (Propositions 2 and 4) provides interesting insights.

Lemma 2 *The reputational gains are always higher in duopoly than in monopoly.*

The reason lies in the availability of additional information in the case of duopoly. First, the presence of two outlets allows the audience to compare their contents, i.e. which states outlets i and j endorsed. Second, it allows the audience to observe the sequence of publication of the two outlets. Together, these two factors allow outlet i to publish after outlet j, match the state correctly, and signal its type more easily. In turn, this makes outlet i more willing to pay the cost of research. However, the additional preemption concerns in duopoly counterbalance this positive information effect, and makes c_D decreasing in v. The two effects combined yield our first main result pertaining to the effect of Internet-driven competition on reporting.

[16]For the rest of the paper and in the proofs, we eliminate σ_i, σ_j or σ^* from $\gamma(.)$ to ease the notation.

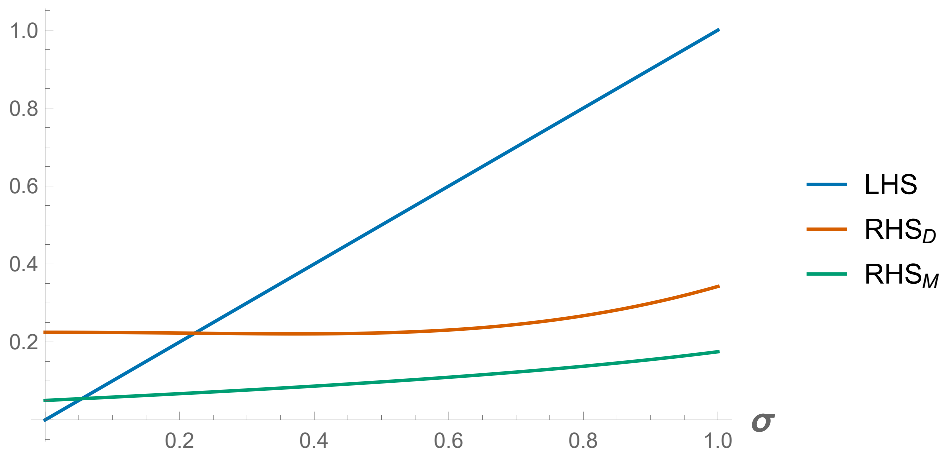

Figure 1: Equilibrium σ_D^* and σ_M^* for when $\pi = .6$, $v = .3$, $\bar{c} = 2$ and $\varepsilon = .1$

Proposition 5 *There exists a nonempty interval of v values where $\sigma_D^* > \sigma_M^*$.*

Basically, what Proposition 5 says is that there is a nonempty set of parameters where research is more likely in duopoly than in monopoly. Therefore, competition may lead to better reporting.

A good way to illustrate Proposition 5 is Figure 1. The orange line is $F(c_D)$, the green line is $F(c_M)$ and the blue one is the 45° line. The equilibrium probability of research is given by the point of intersection of $F_c(c_D)$ and $F_c(c_M)$ with the 45° line. It is clear that $\sigma_D^* > \sigma_M^*$ for sufficiently small v.

Intuitively, reputational gains in monopoly are given by the increased probability of getting the state right. In duopoly, the audience can use one extra piece of information – the action of the other outlet, which includes the outcome of verification and the sequence of publication. Hence, competition induces a trade off between those two forces pushing in opposite directions. Importantly, this trade off is not obvious. The main point of Proposition 5 is precisely to point out that, contrary to the wisdom of the crowd in media studies literature, competition does not necessarily lead to a faster release of less accurate information.[17]

3.4 The role of audience's information

The previous results relied critically on what the audience observes from the competition, or simply the "transparency". To build further intuition, here we analyze how changing the transparency affects our result. In general, the effect of transparency on the possibility that competition induces better reporting is non-monotonic. To see why, consider the two other possibilities – nothing about the timing

[17] In Drago, Nannicini, and Sobbrio (2014), the authors empirically show a positive effect of new newspaper outlet entry on voter turnout in municipal elections, the reelection probability of the incumbent mayor, and the efficiency of the municipal government using Italian municipal elections data between 1993-2010. While not a direct evidence of our results, more information that the voters get with more outlets is likely driving the result in their paper.

is observable and the timing of research is fully observable. Our original assumption lies in the middle of this increasing transparency spectrum. Of course, the content of publication is always visible to the audience, i.e. the audience observes m.

Unobservable timing or zero transparency. Suppose the audience observes neither the timing of publication nor the sequence of publication. It simply consumes the content of the outlet publishing the story. In this case, the behavior of the monopolist is exactly as before. Hence, $c_M = (1-\pi)(\gamma(R)-\gamma(W))$ does not change. In the case of duopoly, however, the endorsement of the other outlet does not matter anymore in the updating. The audience considers each outlet separately because nothing about the timing is observed. Therefore, $\gamma(R, .) = \gamma(R)$ and $\gamma(W, .) = \gamma(W)$. The consequence is summarized in the following corollary.

Corollary 1 *If neither time nor the sequence of publication are observable,*

$$c'_D = c_M - \frac{1}{2}v$$

and therefore, $c'_D < c_M$ for every strictly positive v.

Intuitively, there are no additional reputational gains because it is not easier to "look good" in the presence of a competitor. In fact, the reputational part of the cost threshold is exactly the same. But the additional risk of preemption pushes c_D down.

Observable timing or full transparency. If the timing of publication is observable, the monopolist can fully differentiate itself by publishing in period 2. This is possible because the audience can now perfectly distinguish between period 1 and 2, and therefore, is fully aware of whether research was conducted or not. Moreover, this is true in duopoly as well. In fact, the actual content of the publication does not matter for the reputation-building, and differentiation is driven entirely by the timing. As a consequence, the logic applies as before. The reputational part of the threshold is the same, but preemption concerns reduce the incentives to investigate and conduct research.

Corollary 2 *If the timing of publication is observable,*

$$c''_M = 1 - \gamma(1) \text{ and } c''_D = 1 - \gamma(1) - \frac{1}{2}v$$

where $\gamma(1) = \frac{1-\sigma}{2-\sigma}$. Therefore, $c''_D < c''_M$ for every strictly positive v.

Note that now the cost thresholds are bigger than in the previous information environments. This is so because now maximum distinction is possible between the two outlets. Therefore, the actual levels of reputational benefits are also higher. This is captured in the belief updating,

$$\gamma(1) = \frac{1-\sigma}{2-\sigma} \text{ but now } \gamma(2) = 1.$$

It is worth emphasizing that both of these extreme transparency assumptions are somehow problematic. Completely unobservable timing clashes with the idea of a scoop value, or more generally with the preemptive nature of the media market. If the audience has no understanding of when the publication happened, there is nothing to gain from being first. There are only gains from ultimate publication. This is obviously not true in reality. Completely observable timing, on the other hand, implies that the reader perfectly understands exactly how much research went into an article. Therefore, the whole differentiation happens on the time dimension, rather than on the truthfulness of the story. Again, this hardly seems true in reality.

4 Stories and the effect of better initial information

We are now in a position to discuss what kinds of stories are susceptible to more speed-driven journalism and what aren't. To do so, we place more restrictions on audience preferences.

Let there be a unit mass of audience. The audience decides on whether to take an action or not. Let this action be denoted by $\alpha \in \{a, b\}$ and interpreted as "matching the state". The audience seeks out the information published by the outlets and consumes their content to the extent it wants to match its action to the story. Examples include decisions on who to vote or to form opinions. Note that the audience also has an option not take the action at all and therefore, not opt for any outlet.

For any given story, a fraction u of this audience requires the information urgently. The preferences of the urgent audience is given by

$$V_u = \begin{cases} 1 \text{ if deciding today and } \alpha = \omega, \\ 0 \text{ if deciding today and } \alpha \neq \omega, \\ -k \text{ if remaining undecided or deciding tomorrow} \end{cases}$$

where 'today" happens for the audience when the first outlet publishes its content. So, when the outlets publish sequentially, there is a clear notion of today and tomorrow. However, when the outlets publish simultaneously, today happens at that time period.[18]

[18]Today and tomorrow are essentially defined along $t = 1$ and 2. They both happen before the true story in eventually revealed.

The remaining audience, a fraction $1-u$, is patient. Its preference, on the other hand is given by

$$V_{1-u} = \begin{cases} 1 \text{ if } \alpha = \omega, \\ -k \text{ if } \alpha \neq \omega, \\ 0 \text{ if remaining undecided.} \end{cases}$$

Observe that the patient audience does not care about when it makes the decision. Taking an accurate decision matters more. Notably, the difference between the urgent and the patient audience lies in how they value making a wrong decision. Assuming k to be sufficiently large, it matters more to the urgent audience to make a decision as soon as the first outlet publishes. For the patient audience, on the other hand, it matters more to not make an incorrect decision. Therefore, it chooses to remain uninformed (i.e. does not consume the content) if it is unsure about whether the story has been researched or not. Specifically, when the outlets publish simultaneously, the patient audience prefers to remain undecided and uninformed than to take the wrong action.[19]

Given these preferences, the audience picks its most preferred outlet. Type u audience always consumes content from the first outlet to publish the story, and $1-u$ picks the second one, if there is one. When both of the outlets publish simultaneously, then only u types are available. This audience chooses one of the outlets randomly. Therefore, u is akin to v, or the scoop value from the previous analysis. In addition, we assume that the entire mass of audience is available for reputation building.

u is story-specific and when the outlets get a story they also learn perfectly the value of u. The idea is that those stories with a relatively high u are more urgent than others. These could include, for example, information about whether a company has gone bankrupt, or whether the police caught the terrorists, etc.

First, observe that nothing changes relative to the monopoly case discussed in Proposition 2. As there is no sense of time order, the audience preference for urgency does not alter the equilibrium. However, now the duopoly case looks different. Noting that the belief updating remains the same, the

[19]We treat each of the two subgroups that compose the audience as a single entity, as the preferences of their members are identical. If they have different information, e.g. because half of the group consumes one outlet and half the other, and outlets endorse different states, we assume they choose the action by tossing a fair coin. Note that subgroup payoffs depend on the decision of the subgroup, not on the collective decision of the audience as a whole.

new condition for outlet i conducting research becomes

$$\overbrace{\frac{1}{2}\left[\sigma^j\left(\frac{u}{2}+\gamma^i(\varnothing)\right)+(1-\sigma^j)(1-u+\gamma^i(2))\right]+\frac{1}{2}(1-u+\gamma^i(2))-c^i}^{\text{expected payoff from research}} \geq$$
$$\underbrace{\frac{1}{2}\left[\sigma^j(u+\gamma^i(1))+(1-\sigma^j)\left(\frac{u}{2}+\pi^2\gamma^i(\varnothing)+(1-\pi^2)\gamma^i(1)\right)\right]+\frac{1}{2}\left(\frac{u}{2}+\pi^2\gamma^i(\varnothing)+(1-\pi^2)\gamma^i(1)\right)}_{\text{expected payoff from publication}},$$

which simplifies to

$$c^i \leq \frac{1}{2}\left[\left(\gamma^i(\varnothing)-\gamma^i(1)\right)\left(\sigma^j-(2-\sigma^j)\pi^2\right)+(2-\sigma^j)\left(1-\gamma^i(1)\right)-\sigma^j(1-u)\right]+1-\frac{3}{2}u := \bar{c}^i_D. \quad (2)$$

Observe in condition (4) that the incentives to research have increased. By researching and being the second one to publish the story, the outlet gets an additional $1-u$ readers on top of building a perfect reputation. Said another way, this dilutes preemption concerns as both the first and the second mover have their respective markets. Therefore, we first need to check if a symmetric and unique equilibrium $\bar{c}_D$ exists à la Proposition 4.

Proposition 6 *Let there be a fraction u of audience available to the first outlet publishing and let $\bar{c} \geq 2.5$. If there are two media outlets and θ is not known to the audience, there exists a unique and symmetric equilibrium where $\bar{\sigma}^{i*} = \bar{\sigma}^{j*} := \bar{\sigma}^* = F(\bar{c}_D)$ such that*

$$\bar{c}_D = \frac{1}{2}\left[\left(\gamma(\varnothing)-\gamma(1)\right)\left(\bar{\sigma}^*-(2-\bar{\sigma}^*)\pi^2\right)-\bar{\sigma}^*(1-u)\right]+\frac{3}{2}(1-u)$$

where $\gamma(\varnothing) = \frac{(\bar{\sigma}^*)^2+(1-\bar{\sigma}^*)(2-\bar{\sigma}^*)\pi^2}{(\bar{\sigma}^*)^2+(2-\bar{\sigma}^*)^2\pi^2}$ and $\gamma(1) = \frac{1-\bar{\sigma}^*}{2-\bar{\sigma}^*}$.

Note that while v was unbounded, $u \in [0,1]$. But an increase in the fraction of urgent audience u still has a negative effect on $\bar{c}_D$ and decreases $\bar{\sigma}^*$. Therefore, a high fraction of impatient audience pushes the outlets towards speed. The next proposition compares the probabilities of research in the no-competition monopoly case with the duopoly case on the basis of u.

Proposition 7 *There exists an interior u, $\bar{u} \in (0,1)$ such that*

- *for stories with $u < \bar{u}$, $\bar{c}_D > c_M$ so that research by high outlets in duopoly is more likely than in monopoly ($\bar{\sigma}_D > \sigma_M$);*
- *for stories with $u > \bar{u}$, $\bar{c}_D < c_M$ so that research by high outlets in duopoly is less likely than in monopoly ($\bar{\sigma}_D < \sigma_M$); and*

- *for stories with $u = \bar{u}$, $\bar{c}_D = c_M$ so that research by high outlets in duopoly is equally likely as in monopoly ($\bar{\sigma}_D = \sigma_M$).*

We can therefore see that competitive environments are better for research on non-urgent topics. A good example is the recent *New York Times* exposé on sexual abuse in Hollywood. It is reasonable to believe that sexual abuse in the movie industry does not directly impact a large fraction of society. Yet, it was an important finding that will have a long-run impact as women come forward and demand justice, and organizations respond. On the flip side, investigations and research on urgent topics is less likely in competitive environments. The example of terrorist attacks fits perfectly in this setting. In fact, after the Boston Marathon Bombings in April 2013 there was much confusion in the media and articles were published without fact-checking. The intuition is simple: when a large fraction of the audience seeks information quickly, outlets compete to be the first one to publish the news.

We can now also make assessments about the audience's welfare.[20] The audience's welfare V is defined as follows

$$V = \left[\left(\frac{1}{2}\right)^2 + 2\frac{1}{4}(1-\bar{\sigma}^*) + \left(\frac{1}{2}\right)^2 (1-\bar{\sigma}^*)^2\right]\pi u + 2\frac{1}{4}\bar{\sigma}^*\left[1 + (1-\bar{\sigma}^*)\right](1-u+\pi u) + \left(\frac{1}{2}\right)^2 (1-(1-\bar{\sigma}^*)^2)u$$

$$= \frac{(4-(\bar{\sigma}^*)^2)}{4}\pi u + \frac{1}{2}\bar{\sigma}^*(2-\bar{\sigma}^*)(1-u) + \frac{1}{4}(1-(1-\bar{\sigma}^*)^2)u.$$

The first term is the probability that the two outlets move together but do not research further, i.e. they publish in $t = 1$. As a result, the probability of matching the state is π and only fraction u of the audience gets this payoff. The second term is the probability that the outlets move sequentially, in which case the fraction $1 - u$ match the state, but fraction u only match it with probability π. Finally, the third is when both outlets move together in $t = 2$ after researching further. In this case, they match the state perfectly but fraction $1 - u$ does not receive this payoff.

As discussed in Section 1, another important effect of the Internet has been to make it easier to conduct preliminary research. Emails and social media make it particularly easy to share pictures, video and text from any part of the world. One way to interpret it is as an increase in π or the precision of s. This, Knobel (2018) argues, should lead to better reporting. We show below that that is not necessarily true. Our next proposition shows that the overall effect of an increase in π on V is dependent on the kind of story u being explored.

Proposition 8 *There exists an interior u, $\bar{u}^V \in (0, 1)$, such that if $u < \bar{u}^V$ an increase in precision π of initial signal s decreases the overall welfare V.*

[20] Note that even if the audience knows that outlets may be publishing without research, it is still better to listen to the outlets rather than to follow the priors in decision-making.

The intuition for this somewhat surprising result is easy. The equilibrium probability of research falls as precision π increases. This is because a higher π reduces the reputational gain that comes with separation. The audience attributes correctly matching the state more to better initial information that comes costlessly due to better technology rather than actual research. Preemption concerns, therefore, become more salient and push the outlets towards speed. In turn, it hurts the average audience if it is composed of more patient types, i.e. u is low and then π increases.

Formally, the welfare of the urgent audience increases with an increase in π.

$$\frac{\partial V|_u}{\partial \pi} = \frac{(4-\bar{\sigma}^2)}{4} + \left[-\pi\frac{2\bar{\sigma}}{4} + 2\frac{1-\bar{\sigma}}{4}\right]\frac{\partial \bar{\sigma}}{\partial \pi} > 0$$

because $\frac{(4-\bar{\sigma}^2)}{4} > \frac{1-\bar{\sigma}}{2}$. And the welfare of the patient audience reduces due to an increase in π,

$$\frac{\partial V|_{1-u}}{\partial \pi} = (1-\bar{\sigma})\frac{\partial \bar{\sigma}}{\partial \pi} < 0.$$

When the fraction of urgent audience is low enough, an increase in π hurts an average audience member. Better preliminary research is good news for the audience only if separation does not happen and is not desired. However it also discourages separation, which hurts the audience when it is desired.

5 Information dissemination by a source

We now turn back to our original model and discuss the case of a strategic source. We can use our model to determine how a source can share information with media outlets.

In general, our strategic source's preferences are summarized by the following objective function,

$$\mathbb{1}\{\text{publication in } t=1\} + \mu \Pr(\text{matching the state}).$$

Therefore, the source has a preference for speed vs. accuracy. The parameter $\mu \geq 0$ captures the weight that the source places on accurate information from at least one outlet *vis-à-vis* having at least one outlet publishing in period 1. For instance, a concerned citizen or an employee in a firm witnessing some wrongdoing might have a high preference for accuracy. On the flip side, a politically-motivated source who merely wants to get some potentially incorrect information out quickly will have a low preference for accuracy. We want to determine whether a source wants to share information with one or both the outlets to fulfill her objective.

In line with our model, we will assume that if the source shares a story with both of the outlets, both are aware that the other also possesses the same story. Therefore, the information is shared "publicly".[21] But when the source shares information with just one outlet, we will assume that the other is unaware. This allows the outlet with a story to effectively behave as a monopolist from our analysis in Section 3.1. In addition, we assume that the source possesses a story of a fixed precision π. She makes her decision about who to share the story with at the beginning of the game before time 0. The type of the outlet is still each outlet's private information; the source does not have this information when making her decision.

First, we make a simple observation that follows from our analysis of monopoly and duopoly. (In what follows, we drop the star notation for convenience with an understanding that we are talking about equilibrium values.)

Corollary 3 *The equilibrium probability of research by a high outlet in monopoly is $\sigma_M > 0$ while in duopoly is $\sigma_D \geq 0$.*

Corollary 3 is an important one. It highlights that while in monopoly the probability of research is always positive; in duopoly it might be zero if v is sufficiently high. This corollary will help us outline the behavior of a source who is aware of how high v is associated with her story.

Second, we write down the expected utility of the source for the equilibrium research probabilities that will be induced in the following subgame. The expected payoff from sharing information with one outlet is

$$\frac{1}{2}(1+\mu\pi) + \frac{1}{2}[\sigma_M\mu + (1-\sigma_M)(1+\mu\pi)] \tag{3}$$

The first term reflects what the source gets if she gives the story to a low quality outlet, and the second term is for giving it to a high quality outlet. Similarly, the expected payoff from sharing information with both the outlets is

$$\frac{1}{4}(1+\mu\pi) + \frac{1}{4}[1+\mu(\sigma_D + (1-\sigma_D)\pi)]2 + \frac{1}{4}[(1-\sigma_D)^2(1+\mu\pi) + 2\sigma_D(1-\sigma_D)(1+\mu) + \sigma_D^2\mu]. \tag{4}$$

Again, the first term reflects the source's payoff from facing two low type outlets. The second is the payoff from facing one high type and one low type outlet. Note that in this case the story is always published in the first period, but the high outlet matches the state only if it does research. The third term is the payoff from facing two high type outlets. Here, the possible situations are that neither

[21] One may imagine a politician revealing some negative evidence about a competitor on Twitter as an example. It is common for news outlets to pick up this information and relay it, either as is or after further fact-checking and investigations.

researches; one researches, or both research. The following lemma helps simplify the source's optimal response for a given σ_M and σ_D.

Lemma 3 *The source's best response can be summarized as follows:*

- *The source prefers to share the story with both the outlets unambiguously for any* $\mu \geq 0$ *if* $\frac{\sigma_D^2}{2} \leq \sigma_M \leq \frac{\sigma_D(4-\sigma_D)}{2}$.
- *Otherwise, the source prefers to share the story with both outlets if*

$$\mu(1-\pi)(2\sigma_M - \sigma_D(4-\sigma_D)) \leq 2\sigma_M - \sigma_D^2$$

The lemma shows that there is a range of equilibrium σ_M and σ_D for which the source always prefers to send information to both the outlets independent of μ. Interestingly, this region lies around the $\sigma_D = \sigma_M$ line. Therefore, the lemma shows that for σ_M and σ_D close to each other there is reason to prefer both outlets. To understand why, let us break this down into two further statements.

First, there are parameters where one outlet alone is more likely to research than when it is competing with another (i.e. $\sigma_M > \sigma_D$) and μ is very large, and yet the source prefers to share the story with two outlets. This happens because a lower σ_D is compensated by a higher probability of investigation from more firms. But this requires σ_D and σ_M to be close to each other. To see this, let us compare the total probability of research (and matching the state) from sharing the story with one vs. both the outlets. When shared with one it is equal to $\frac{1}{2}\sigma_M$. When shared with both it is given by

$$\frac{1}{4}[\sigma_D^2 + 2\sigma_D(1-\sigma_D)] + \frac{2}{4}\sigma_D = \sigma_D - \frac{\sigma_D^2}{4}.$$

Therefore, despite $\sigma_M > \sigma_D$ the source shares the story with both outlets if $\sigma_D - \frac{\sigma_D^2}{4} \geq \frac{1}{2}\sigma_M$. This condition simplifies to give us our upper bound

$$\sigma_M \leq \frac{\sigma_D(4-\sigma_D)}{2}.$$

Second, there are parameters where one firm is less likely to research than two (i.e. $\sigma_M < \sigma_D$) and μ is very low, and yet the source prefers to share the story with two outlets. This, on the other hand, happens because competition between two firms ensures the story comes out quicker despite each independent outlet researching with a higher probability. To see this, we now compare the total probabilities of the story being published in $t = 1$ under the two scenarios. When shared with one, this

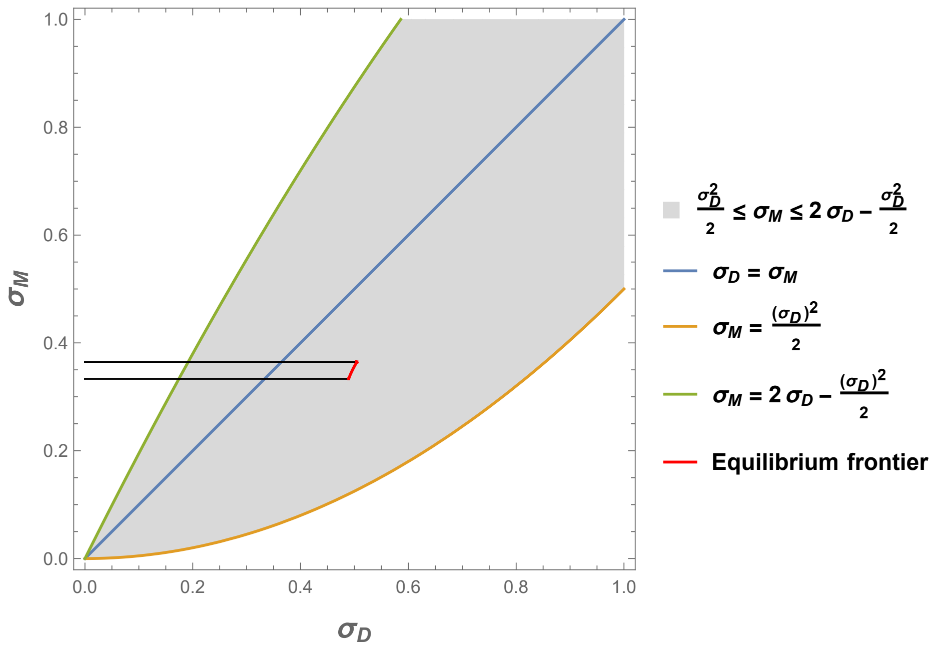

Figure 2: Equilibria in $\sigma_D - \sigma_M$ space and the behavior of the source

probability is equal to $\frac{1}{2} + \frac{1}{2}(1 - \sigma_M) = 1 - \frac{\sigma_M}{2}$. When shared with both it is given by

$$\frac{1}{4} + \frac{2}{4} + \frac{1}{4}[(1 - \sigma_D)^2 + 2\sigma_D(1 - \sigma_D)] = 1 - \frac{\sigma_D^2}{4}.$$

So, now despite $\sigma_M < \sigma_D$ the source shares the story with both outlets if $1 - \frac{\sigma_D^2}{4} \geq 1 - \frac{\sigma_M}{2}$. This condition simplifies to

$$\sigma_M \geq \frac{\sigma_D^2}{2},$$

giving us our lower bound. But note again that for this argument to work σ_D and σ_M should not be too different from each other. When this is the case, then what the source does depends on her preference μ (captured in the second bullet point of Lemma 3).

In Figure 2, the shaded gray region shows the combinations of σ_D and σ_M where the source always prefers to share stories with both outlets. The region is enclosed between $\sigma_M = \frac{\sigma_D(4-\sigma_D)}{2}$ (green) and $\sigma_M = \frac{\sigma_D^2}{2}$ (orange), which includes $\sigma_M = \sigma_D$ (blue).

We now look at possible equilibria that can arise in the $\sigma_D - \sigma_M$ space relative to the source's preferences. We begin by plotting an equilibrium frontier for a given $\bar{c}$ and ε.

Definition 1 (Equilibrium frontier) *The equilibrium frontier is given by the combination of equilibrium σ_D and σ_M generated by varying $\pi \in [.5, 1]$ for $v = 0$ and a fixed $\bar{c}$ and ε.*

The equilibrium frontier, therefore, shows the maximum equilibrium value that σ_D can take for any equilibrium σ_M (since σ_D is decreasing in v from Corollary 3 and we are setting $v = 0$). As proved in Lemma 2, when $v = 0$, $\sigma_D > \sigma_M$. Therefore, the frontier lies to the right of the 45° line. In addition, note that it is upwards sloping. The positive slope is a result of the fact that both σ_M and σ_D are decreasing functions of π.[22] A north-east movement along the frontier arises due to a decrease in π. Figure 2 plots the equilibrium frontier for $\bar{c} = 2$ and $\varepsilon = 1$ in red.[23]

Once we have the equilibrium frontier, it is easy to see the set of all possible equilibrium values that might arise for different parameter ranges. Particularly, increasing v is a leftward movement from the frontier along the same σ_M. For v sufficiently high, $\sigma_D = 0$ while $\sigma_M > 0$ (see Corollary 3). We are now left with comparing these equilibrium values with what the source wants.

Proposition 9 *For a source with preferences given by $\mu \geq 0$,*

- *there exists an $\varepsilon > 0$ small enough and two thresholds $\bar{v} > \underline{v}$ such that if $v < \underline{v}$ the source sends the story to both if $\mu \geq \frac{\sigma_D^2 - 2\sigma_M}{\sigma_D(4-\sigma_D) - 2\sigma_M} \frac{1}{(1-\pi)}$, if $\bar{v} \geq v \geq \underline{v}$ the source always sends the story both, and if $v > \bar{v}$ the source sends the information to both if $\mu \leq \frac{2\sigma_M - \sigma_D^2}{2\sigma_M - \sigma_D(4-\sigma_D)} \frac{1}{(1-\pi)}$;*
- *there exists an $\varepsilon > 0$ large enough and a threshold $\bar{\bar{v}}$ such that if $v \leq \bar{\bar{v}}$ the source sends the story to both, and if $v > \bar{\bar{v}}$ the source sends the information to both if $\mu \leq \frac{2\sigma_M - \sigma_D^2}{2\sigma_M - \sigma_D(4-\sigma_D)} \frac{1}{(1-\pi)}$.*

Our third main result follows by setting $\mu = 0$ in the above proposition. It pertains to the situation where the source only cares about getting the story out quickly independent of whether it is accurate or not. Political actors are often interested in doing so to highlight their achievements or to bring out potentially damaging information about their competitors. Twitter and other social media platforms are one way to communicate such stories, which are then picked up by media outlets and relayed to the public without further research.

Corollary 4 *When the source does not care about accuracy, i.e. $\mu = 0$,*

- *there exists an $\varepsilon > 0$ small enough and $\bar{v}$ such that for $v < \bar{v}$, the source sends the story to one outlet, and sends to two in all other cases, and*
- *there exists an $\varepsilon > 0$ large enough such that the source sends the story to both outlets.*

The proof of both Proposition 9 and its corollary is by construction. The idea is that when ε is small, (at least a part of) the frontier lies below the orange line in Figure 2. Therefore, there arise two thresholds on v where only the middle part lies between the two curves. For a ε high enough, there

[22] The proofs have been omitted from the main text for the sake of brevity.

[23] We choose a high value of ε for graphical representation only. When ε is low, the range of σ_M and σ_D is also small, and it becomes difficult to clearly see the equilibria graphically.

is only one threshold on v as depicted in the figure. One can easily get the result of Corollary 4 by setting $\mu = 0$ in Proposition 9.

Consider the intuition for the case of $\mu = 0$. When the intrinsic motivation to conduct research is high then independent of whether only one outlet has the story or both, the outlets are more likely to conduct research. This is, however, not something a $\mu = 0$ source desires. By sending to both, she is able to create preemption risk as well (even for a low v). This improves on the situation of sending to one as the outlets are more driven towards speed. On the other hand, when intrinsic motivation is low, outlets are less likely to research. Now, the source does not always want to share the story with both. Notably, when v is low the source wants to share information with just one. Sending to both risks the outlets trying to separate by doing research, thereby increasing the overall probability of research. However, again when v is high, the source is happy to share the story with both as preemption concerns will become salient for the outlets.[24]

6 Conclusion

There have been increasing concerns in the past decade about how the Internet has altered the incentives of media outlets. Notably, media critics have argued that increasing competition in the Interent era has pushed outlets towards speed-driven journalism. Our model shows that conventional wisdom about the effect of competition and the modern digital environment on the media market should be taken *cum grano salis*. We prove that competition in itself may make it easier for high quality outlets to engage in more research-driven journalism to separate themselves from the low quality outlets. For this to happen, it must be that the action of one of the outlets is somehow informative about the type of the other. This result and intuition finds support in some of the new media studies literature such as in Knobel (2018) and Carson (2019).

It is, however, worth emphasizing the importance of a "sophisticated" audience in generating the better-reporting result. We need the audience to place importance on the accuracy of stories, and not always seek quick information. Gentzkow and Shapiro (2008) suggest that scoop value is usually not too high in the media markets. But at the same time, some media scholars have argued that the audience usually seeks information earlier on social media. Similarly, our model shows the importance of the audience observing the *sequence* of publication. This might also be an issue if technology deters so. Lionel Barber, the Editor of *Financial Times*, points out, "Technology has (also) flattened the digital

[24]The intuition for the general case presented in Proposition 9 is similar but it is not easy to make sharp predictions like we could with $\mu = 0$ case. However, some additional predictions can be made by choosing specific μ values. For instance, when v is very high so that $\sigma_D = 0$, the source prefers to send to one outlet only if $\mu > 2$.

plain, creating the illusion that all content is equal. It has made it possible for everyone to produce and distribute content that looks equally credible". Thus, outlets cannot only count on their pre-existing reputation to attract readers, and being the first to break the news is increasingly important.

Our paper is one of the first to incorporate preemption and reputation concerns in a single model by thinking of a natural setting where both incentives play a role. However, there is further scope for research here. For instance, one may expand the model to include news media bias. Bias and the speed-accuracy tradeoff can interact in interesting ways. If bias makes reputational gains less salient (e.g. because future readership does not depend on reputation) then it should push toward speed. On the other hand, if bias implies a less informative publication and hence a smaller "scoop value", then it may actually push toward accuracy.

Our model also produces important testable predictions about how the modern digital environment has altered the media landscape. First, we should see better reporting of non-urgent issues in the Internet-age as the outlets try to build a reputation on such stories. Second, the effect of the Internet on the reporting of breaking-news type stories is ambiguous. It might improve because of better source information but might deteriorate because of more time pressure.

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Appendices

A Proofs from the main text

Proof of Observation 1

Proof. Suppose that the outlet choose $d = pub$. Without loss of generality, suppose that $s^i = a$. It is easy to see that $\Pr(\omega = a|s^i = a) > \Pr(\omega = b|s^i = a)$ because

$$\frac{\pi\frac{1}{2}}{\pi\frac{1}{2} + (1-\pi)\frac{1}{2}} > \frac{(1-\pi)\frac{1}{2}}{\pi\frac{1}{2} + (1-\pi)\frac{1}{2}}$$

which is true because $\pi > \frac{1}{2}$. ■

Proof of Lemma 1

Proof. First part. Without loss of generality, suppose that $s^i = a$. Then, if i chooses to publish, it will endorse state a, i.e. send message $m = a$. by Bayes' rule,

$$\Pr(\omega = a|s^i = a) = \frac{\pi\frac{1}{2}}{\pi\frac{1}{2} + (1-\pi)\frac{1}{2}} = \pi$$

as claimed.

Second part. We are interested in the probability that j matches the state from choosing $d = pub$ when i has received a signal s^i. This is equal to

$$\Pr(s^j = a|s^i)\Pr(\omega = a|s^j = a \,\text{and}\, s^i) + \Pr(s^j = b|s^i)\Pr(\omega = b|s^j = b \,\text{and}\, s^i) \tag{A.1}$$

Note that, for a generic s^j, by Bayes' rule we have that $\Pr(s^j|s^i) = \frac{\Pr(s^j \,\text{and}\, s^i)}{\Pr(s^i)}$ and

$$\Pr(\omega = s^j|s^j \,\text{and}\, s^i) = \frac{\Pr(s^j \,\text{and}\, s^i|\omega = s^j)\Pr(\omega = s^j)}{\Pr(s^j \,\text{and}\, s^i)}$$

As a consequence, (A.1) can be simplified to

$$\frac{\Pr(s^j = a \,\text{and}\, s^i|\omega = a)\Pr(\omega = a)}{\Pr(s^i)} + \frac{\Pr(s^j = b \,\text{and}\, s^i|\omega = b)\Pr(\omega = b)}{\Pr(s^i)} \tag{A.2}$$

However, since signals are independent conditional on the state,

$$\Pr(s^j \text{ and } s^i|\omega = s^j) = \Pr(s^j|\omega = s^j)Pr(s^i|\omega = s^j)$$

Moreover, $\Pr(s^j|\omega = s^j) = \pi$. Hence, (A.2) becomes

$$\pi \frac{\Pr(s^i|\omega = a)\Pr(\omega = a) + \Pr(s^i|\omega = b)\Pr(\omega = b)}{\Pr(s^i)} = \pi$$

as claimed. ■

Proof of Proposition 2

Proof. Suppose that a high type outlet chooses $d = res$ with probability σ. Reminding ourselves from the main text that

$$\gamma(R) = \frac{\sigma + (1-\sigma)\pi}{\sigma + (1-\sigma)\pi + \pi}$$

$$\gamma(W) = \frac{(1-\sigma)(1-\pi)}{(1-\sigma)(1-\pi) + (1-\pi)} = \frac{1-\sigma}{2-\sigma}$$

from Bayes' rule and using the fact that a low type outlet always chooses *pub*.

A high type outlet optimally chooses *res* if

$$\gamma(R) - c \geq \pi\gamma(R) + (1-\pi)\gamma(W) \implies c \leq (1-\pi)(\gamma(R) - \gamma(W)) := c_M$$

In equilibrium the conjectured σ must be equal to the actual one, hence it must be that

$$\sigma^* = F(c_M(\sigma^*)) = \frac{c_M(\sigma^*) + \varepsilon}{\bar{c} + \varepsilon}. \tag{A.3}$$

We need to check if such a fixed point exists. To do so, three observations are in order. First, note that both the LHS and RHS of the above are continuous in σ^*. Second, $\text{LHS}(\sigma^* = 0) = 0 < \text{RHS}(\sigma^* = 0) = \frac{\varepsilon}{\bar{c}+\varepsilon}$ (as $c_M = 0$ at $\sigma^* = 0$). Third, $\text{LHS}(\sigma^* = 1) = 1 > \text{RHS}(\sigma^* = 1) = F(\frac{1-\pi}{1+\pi})$. Therefore, the above is true.

Finally, we need to check for the uniqueness of the fixed point. Note that

$$\frac{\partial \text{RHS}}{\partial \sigma^*} = \frac{1-\pi}{\bar{c}+\varepsilon}\left[\frac{\pi(1-\pi)}{(\sigma^* + (1-\sigma^*)\pi + \pi)^2} + \frac{1}{(2-\sigma^*)^2}\right] > 0,$$

but the sign of

$$\frac{\partial^2 \text{RHS}}{\partial(\sigma^*)^2} = \frac{2(1-\pi)}{\bar{c}+\varepsilon}\left[-\frac{\pi(1-\pi)^2}{(\sigma^*+(1-\sigma^*)\pi+\pi)^3}+\frac{1}{(2-\sigma^*)^3}\right]$$

is not clear immediately. $\frac{\partial^2 \text{RHS}}{\partial(\sigma^*)^2} > 0$ requires

$$-\pi(1-\pi)^2(2-\sigma^*)^3 + (\sigma^*+(1-\sigma^*)\pi+\pi)^3 > 0 \tag{A.4}$$

It is easy to see that the LHS of (A.4) is strictly increasing in σ^* for all $\pi \in (0.5, 1]$. Moreover, the LHS of (A.4) when we substitute $\sigma^* = 0$ is $-1 + 2\pi > 0$. As a consequence, the RHS of (A.3) is strictly increasing and convex. Combined with the above, it means that there is only one fixed point in the $[0, 1]$ interval. ■

Proof of Proposition 3

Proof. If θ is known, then by choosing *pub* in $t = 1$ a high quality outlet receives a payoff of

$$\frac{1}{2}\frac{v}{2} + \frac{1}{2}\left[v\sigma + \frac{v}{2}(1-\sigma)\right] + \mathbb{1}\{\theta = h\},$$

where σ is the (symmetric) probability that the high quality competitor engages in more research. By instead choosing *res* and publishing in $t = 2$ a high type outlet gets a payoff of $\frac{1}{2}\sigma\frac{v}{2} + \mathbb{1}\{\theta = h\} - c$. Comparing the two, each outlet is willing to investigate iff $c \leq -\frac{v}{2}$. As a consequence, $\sigma_D^* = F\left(-\frac{v}{2}\right)$ in symmetric equilibrium. Research happens with positive probability when $-\frac{v}{2} > -\varepsilon$, which can be rearranged to $v < 2\varepsilon$. ■

Proof of Proposition 4

Proof. We complete this proof in several steps. To begin with, we conjecture that whenever an outlet chooses to publish, it is optimal to endorse the state suggested by the signal. This will be verified at the end of the proof.

Step 1: We begin by showing that in any signal-based equilibria outlets' period 1 decisions on whether to research or publish is described by a threshold on c. This follows from the discussion in the text. Let σ^i and σ^j be the conjectured strategies. Then equation (1) defines the threshold c_D^i for outlet i.

$$c^i \leq \frac{1}{2}\left[\left(\gamma^i(\varnothing) - \gamma^i(1)\right)(\sigma^j - (2-\sigma^j)\pi^2) + (2-\sigma^j)\left(1-\gamma^i(1)\right)\right] - \frac{1}{2}v := c_D^i \tag{1}$$

where $\gamma(\varnothing) = \frac{\sigma^i\sigma^j + (1-\sigma^i)(2-\sigma^j)\pi^2}{\sigma^i\sigma^j + (2-\sigma^i)(2-\sigma^j)\pi^2}$ and $\gamma(1) = \frac{1-\sigma^i}{2-\sigma^i}$. The problem is identical for player j.

Step 2: Next, we show that for any σ^j there is only one σ^i that solves the equilibrium fixed point for player i.

Given that cost is uniformly distributed in $[-\varepsilon, \bar{c}]$ and that, in equilibrium the conjectured probability of investigation must be equal to the actual probability, the equilibrium levels of σ^i and σ^j must be the solutions of

$$\sigma^i = F(c_D^i(\sigma^i, \sigma^j)) \text{ and } \sigma^j = F(c_D^j(\sigma^j, \sigma^i))$$

where

$$F(c_D^i(\sigma^i, \sigma^j)) = \begin{cases} 0 & c_D^i(\sigma^i, \sigma^j) < -\varepsilon \\ \frac{c_D^i(\sigma^i, \sigma^j) + \varepsilon}{\bar{c} + \varepsilon} & -\varepsilon \le c_D^i(\sigma^i, \sigma^j) \le \bar{c} \\ 1 & c_D^i(\sigma^i, \sigma^j) > \bar{c} \end{cases}$$

and

$$f(c_D^i(\sigma^i, \sigma^j)) = \begin{cases} 0 & c_D^i(\sigma^i, \sigma^j) < -\varepsilon \\ \frac{1}{\bar{c} + \varepsilon} & -\varepsilon \le c_D^i(\sigma^i, \sigma^j) \le \bar{c} \\ 0 & c_D^i(\sigma^i, \sigma^j) > \bar{c} \end{cases}$$

We want to show that, for every σ^j, there is only one σ^i that solves $\sigma^i = F(c_D^i(\sigma^i, \sigma^j))$.

1. The LHS is linear, with slope equal to 1, starting at 0 and ending at 1.
2. As $c_D^i(\sigma^i = 1, \sigma^j) < 1 < \bar{c}$, the RHS evaluated at $\sigma^i = 1 < 1 =$ LHS at $\sigma^i = 1$;
3. The RHS evaluated at $\sigma^i = 0$ is greater than or equal to zero.
4. For any σ^j, both LHS and RHS are continuous in σ^i.

Hence, they cross at least once and there is at least one solution to this fixed point problem.

To show that they cross only once, we need to show that the slope of the RHS is never above 1. First, note that the slope of the RHS is either 0 or $f(c_D^i)\frac{\partial c_D^i}{\partial \sigma^i}$. Second, $\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^i} = \frac{(\sigma^j - (2-\sigma^j)\pi^2)\pi^2(2-\sigma^j)}{(\sigma^i\sigma^j + (2-\sigma^i)(2-\sigma^j)\pi^2)^2}$, whose sign depends on the sign of $(\sigma^j - (2-\sigma^j)\pi^2)$ and $\frac{\partial \gamma^i(1)}{\partial \sigma^i} = \frac{-1}{(2-\sigma^i)^2} < 0$. Using these we can write $\frac{\partial c_D^i}{\partial \sigma^i} = \frac{1}{2}\left[\frac{(\sigma^j - (2-\sigma^j)\pi^2)^2\pi^2(2-\sigma^j)}{(\sigma^i\sigma^j + (2-\sigma^i)(2-\sigma^j)\pi^2)^2} + \frac{2-\pi^2(2-\sigma^j)}{(2-\sigma^i)^2}\right]$ where both terms are always positive. Third, we can show that the sign of $\frac{\partial^2 c_D^i}{\partial(\sigma^i)^2}$ is ambiguous, but $\frac{\partial^3 c_D^i}{\partial(\sigma^i)^3} \ge 0$. As a consequence, the second derivative is always increasing in σ^i and the first derivative is convex in σ^i. So, $\frac{\partial c_D^i}{\partial \sigma^i}|_{\sigma^i=1} > \frac{\partial c_D^i}{\partial \sigma^i}|_{\sigma^i=0}$, and c_D^i reaches its steepest point around $\sigma^i = 1$. Therefore, it is enough to show that $\frac{\partial c_D^i}{\partial \sigma^i}|_{\sigma^i=1} \le 1$. This requires

$$2(\sigma^j + (2-\sigma^j)\pi^2)^2 \geq (\sigma^j - (2-\sigma^j)\pi^2)^2\pi^2(2-\sigma^j) + (\sigma^j + (2-\sigma^j)(1-\pi^2)(\sigma^j + (2-\sigma^j)\pi^2)$$

which further simplifies to

$$(\sigma^j + (2-\sigma^j)\pi^2)^2(2-\sigma^j-2+\sigma^j) \geq -4\sigma^j(2-\sigma^j)^2\pi^4.$$

This latter condition is always verified (strictly for positive σ^j, weakly when $\sigma^j = 0$).

Now, combining the above with the fact that $c_D^i(\sigma^i = 1, \sigma^j) < 1$, implies that they cannot cross more than once.

Step 3: Third, we show that if an equilibrium exists, it is unique for $\bar{c} \geq 2$.

Define $\hat{\sigma}^i(\sigma^j)$ the optimal σ^i for a given σ^j. In equilibrium, it must be that

$$\hat{\sigma}^i(\hat{\sigma}^j(\sigma^i)) = \sigma^i \tag{A.5}$$

Rearranging, the equilibrium is the solution of $\hat{\sigma}^i(\hat{\sigma}^j(\sigma^i)) - \sigma^i = 0$. Differentiating with respect to σ^i, we obtain $\frac{\partial\hat{\sigma}^i}{\partial\hat{\sigma}^j}\frac{\partial\hat{\sigma}^j}{\partial\sigma^i} - 1 = 0$. For the equilibrium to be unique (conditional on its existence), it is now sufficient to show that the LHS is negative. This implies that only one fixed point of (A.5) can be found. This happens when $\frac{\partial\hat{\sigma}^i}{\partial\hat{\sigma}^j}$ and $\frac{\partial\hat{\sigma}^j}{\partial\sigma^i}$ are between -1 and 1. As the players are identical, it is enough to show that this holds for one of them.

To show the above, begin by noting that $\sigma^i(\sigma^j)$ is implicitly defined by the unique solution of $\sigma^i - F(c_D^i(\sigma^i, \sigma^j)) = 0$. (Going forward we drop the $\hat{}$ notation with an understanding that we are concerned with optimal responses.) As $\frac{\partial c_D^i}{\partial\sigma^i}|_{\sigma^i=1} \leq 1$, we can use implicit function theorem. Therefore,

$$\frac{\partial\sigma^i}{\partial\sigma^j} = \frac{\frac{\partial F(c_D^i)}{\partial\sigma^j}}{1 - \frac{\partial F(c_D^i)}{\partial\sigma^i}} \tag{A.6}$$

Consider first the denominator of (A.6). From Step 2, we know that it is always positive. Moreover, it will be smaller the bigger is $\frac{\partial F(c_D^i)}{\partial\sigma^i}$. On the other hand, it is the biggest when $\frac{\partial F(c_D^i)}{\partial\sigma^i}$ is zero. When $\frac{\partial F(c_D^i)}{\partial\sigma^i}$ is non-zero, it is linear and increasing in $\frac{\partial c_D^i}{\partial\sigma^i}$. As this reaches its maximum for $\sigma^i = 1$, we simply replace it and look for a maximum with respect to σ^j.

$$\begin{aligned} max_{\sigma^j} \frac{\partial c_D^i}{\partial \sigma^i}|_{\sigma^i=1} &= \frac{1}{2}\left[\frac{(\sigma^j-(2-\sigma^j)\pi^2)^2\pi^2(2-\sigma^j)}{(\sigma^j+(2-\sigma^j)\pi^2)^2}+2-\pi^2(2-\sigma^j)\right] \\ &= \frac{1}{2}\left[2-\frac{4\sigma^j(2-\sigma^j)^2\pi^4}{(\sigma^j+(2-\sigma^j)\pi^2)^2}\right] \\ &= 1 \end{aligned}$$

where the second equality is a rearrangement and the third one follows from the fact that this is maximized for $\sigma^j = 0$.

As a consequence, $max_{\sigma^i,\sigma^j} \frac{\partial F(c_D^i)}{\partial \sigma^i} = \frac{1}{\bar{c}+\varepsilon}$ and the smallest the denominator can be is $\frac{1}{\bar{c}+\varepsilon}$.

Second, consider the numerator. $\frac{\partial F(c_D^i)}{\partial \sigma^j}$ is either zero or $\frac{1}{\bar{c}+\varepsilon}\frac{\partial c_D^i}{\partial \sigma^j}$. Further, note that

$$\frac{\partial c_D^i}{\partial \sigma^j} = \frac{1}{2}\left[\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}(\sigma^j-(2-\sigma^j)\pi^2)+\gamma^i(\varnothing)+\pi^2(\gamma^i(\varnothing)-\gamma^i(1))-1\right]. \tag{A.7}$$

Finding the overall maximum and minimum is complicated, so we look for sufficient conditions. We start out by looking at $\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}$. After few algebric manipulations, we derive

$$\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j} = \frac{2\sigma^i\pi^2}{(\sigma^i\sigma^j+(2-\sigma^i)(2-\sigma^j)\pi^2)^2}$$

Its sign is positive, but it is hard to determine the maximum. We proceed as follows. First, note that

$$\frac{\partial^2 \gamma^i(\varnothing)}{\partial (\sigma^j)^2} = \frac{-4(\sigma^i-(2-\sigma^i)\pi^2)\sigma^i\pi^2}{(\sigma^i\sigma^j+(2-\sigma^i)(2-\sigma^j)\pi^2)^3}$$

whose sign is ambiguous. However,

$$\frac{\partial^3 \gamma^i(\varnothing)}{\partial (\sigma^j)^3} = \frac{12(\sigma^i-(2-\sigma^i)\pi^2)^2\sigma^i\pi^2}{(\sigma^i\sigma^j+(2-\sigma^i)(2-\sigma^j)\pi^2)^4}$$

which is positive. This implies that (for any σ^i) $\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}$ is a convex function in σ^j which is maximized either at $\sigma^j = 0$ or at $\sigma^j = 1$. By substitution,

$$\begin{aligned} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=0} &= \frac{\sigma^i}{2\pi^2(2-\sigma^i)^2} \\ \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1} &= \frac{2\sigma^i\pi^2}{(\sigma^i+(2-\sigma^i)\pi^2)^2} \end{aligned}$$

Still we are left to determine the maximum possible value of $\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}$ because the comparison is not straightforward. But we can show that for every π, $max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=0} > max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1}$. To prove this, first see that

$$max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=0} = \frac{1}{2\pi^2}$$

But to get $max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1}$,

$$\frac{\partial}{\partial \sigma^i} \left(\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1} \right) = \frac{\partial}{\partial \sigma^i} \left(\frac{2\sigma^i \pi^2}{(\sigma^i + (2-\sigma^i)\pi^2)^2} \right) = \frac{2\pi^2(\sigma^i + (2-\sigma^i)\pi^2) - 4(1-\pi^2)\sigma^i\pi^2}{(\sigma^i + (2-\sigma^i)\pi^2)^3} \tag{A.8}$$

Note that the relevant expression in (A.8) is always positive for $\sigma^i \leq \frac{2\pi^2}{1-\pi^2}$. For a sufficiently high π, this includes the whole range of values of σ^i. Hence, the function is maximised at $\sigma^i = 1$, and

$$max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1} = \frac{2\pi^2}{(1+\pi^2)^2}.$$

But now it is easy to see that $\frac{1}{2\pi^2} \geq \frac{2\pi^2}{(1+\pi^2)^2}$ requires $1 + 2\pi^2 - 3\pi^4 \geq 0$, which is always true for $\pi \in (0.5, 1]$. Therefore, our claim of $max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=0} > max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1}$ is true.

However, for low π, we have that $argmax_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1} = \frac{2\pi^2}{1-\pi^2} \in [0,1]$. In particular, this happens for $\pi^2 \leq \frac{1}{3}$. Even in this case, it is easy to show that $\frac{1}{2\pi^2} \geq \frac{2\pi^2\left(\frac{2\pi^2}{1-\pi^2}\right)}{\left((1-\pi^2)\left(\frac{2\pi^2}{1-\pi^2}\right)+2\pi^2\right)^2}$ requires $\pi^2 \leq \frac{2}{3}$, i.e. it is always the case in the range of parameters of interest. As a consequence, we have that $max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=0} > max_{\sigma^i} \frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}|_{\sigma^j=1}$. Since we want $\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}$ as big as possible, we can set it as $\frac{1}{2\pi^2}$ for our sufficiency conditions.

Given this, the lowest value the numerator of $\frac{\partial \sigma^i}{\partial \sigma^j}$ from (A.6) can be found by making the relevant replacement from above to (A.7). Therefore,

$$min_{\sigma^i,\sigma^j} \frac{\partial F(c_D^i)}{\partial \sigma^i} \geq \frac{1}{\bar{c}+\varepsilon} \frac{1}{2} \left[\frac{1}{2\pi^2}(-2\pi^2) - 1 \right] = \frac{-1}{\bar{c}+\varepsilon}.$$

To see this, note that $min_{\sigma^i,\sigma^j}(\sigma^j - (2-\sigma^j)\pi^2) = -2\pi^2$, $min_{\sigma^i,\sigma^j}\gamma^i(\varnothing) \geq 0$, $min_{\sigma^i,\sigma^j}(\gamma^i(\varnothing) - \gamma^i(1)) \geq 0$. Therefore, our first sufficient condition for the uniqueness of the equilibrium is

$$\frac{-\frac{1}{\bar{c}+\varepsilon}}{1 - \frac{1}{\bar{c}+\varepsilon}} > -1,$$

which simplifies to $\bar{c} \geq 2$, as assumed.

Looking now at the upper bound, again by replacing in (A.7) note that

$$max_{\sigma^i,\sigma^j} \frac{\partial F(c_D^i)}{\partial \sigma^i} \leq \frac{1}{\bar{c}+\varepsilon} \frac{1}{2} \left[\frac{1}{2\pi^2}(1-\pi^2) + 1 + \pi^2 - 1 \right] = \frac{1}{2(\bar{c}+\varepsilon)} \left[\frac{1-\pi^2}{2\pi^2} + \pi^2 \right].$$

To see this, note that $max_{\sigma^i,\sigma^j}(\sigma^j - (2-\sigma^j)\pi^2) = 1-\pi^2$, $max_{\sigma^i,\sigma^j}\gamma^i(\varnothing) \leq 1$, $max_{\sigma^i,\sigma^j}(\gamma^i(\varnothing)-\gamma^i(1)) \leq 1$. Therefore, our second sufficient condition for the uniqueness of the equilibrium is

$$\frac{\frac{1}{2(\bar{c}+\varepsilon)}\left[\frac{1-\pi^2}{2\pi^2}+\pi^2\right]}{1-\frac{1}{\bar{c}+\varepsilon}} < 1$$

The numerator is maximised at $\pi = \frac{1}{2}$, hence the condition simplifies to $\bar{c}+\varepsilon > \frac{15}{16}$. Again, this is satisfied for $\bar{c} \geq 2$.

Step 4: Fourth, we show that a symmetric equilibrium where $\sigma^{i*} = \sigma^{j*} = \sigma^*$ always exists. Therefore, it is also unique among the set of signal-based equilibria.

Because of symmetry, the equilibrium must be the fixed point of

$$\sigma^i = \sigma^j = \sigma^* = F(c_D(\sigma^*)) \tag{A.9}$$

where from (1)

$$c_D(\sigma^*) = \frac{1}{2}\left[\left(\frac{(\sigma^*)^2+(1-\sigma^*)(2-\sigma^*)\pi^2}{(\sigma^*)^2+(2-\sigma^*)^2\pi^2} - \frac{1-\sigma^*}{2-\sigma^*}\right)(\sigma^*-(2-\sigma^*)\pi^2)+1\right] - \frac{1}{2}v$$

Looking at (A.9), note that both LHS and RHS are continuous on the $[0,1]$ interval. Moreover, RHS($\sigma^*=0$) $\geq 0 =$ LHS(σ^*) and $RHS(\sigma^*=1) < 1 = LHS(\sigma^*=1)$. As a consequence, there exists a solution in the $[0,1]$ interval. From the previous steps, we know that this solution is unique.

Step 5: Finally, we show that in the symmetric equilibrium it is optimal to endorse the state suggested by the most informative signal.

Assume that player j behaves as in the equilibrium described above. Now, by endorsing the wrong state in period 2 player i shifts beliefs from $\gamma^i(2)=1$ to $\gamma^i(1)$ if it is the only one publishing in that period, and from $\gamma^i(\varnothing)$ to $\gamma^i(1)$ if both outlets publish in period 2. In both cases, sticking to the correct state is at weakly dominant.

If outlet i chooses to publish in period 1, by endorsing the least likely state outlet i is indifferent if it is the only one to publish in that period. If instead outlet j publishes in period 1 as well, the expected reputation of outlet i by endorsing the state suggested by the signal is $\pi^2\gamma^i(\varnothing)+(1-\pi^2)\gamma^i(1)$. By endorsing the opposite state, the expected reputation is $\pi\gamma^i(1)+(1-\pi)\left[\pi\gamma^i(\varnothing)+(1-\pi)\gamma^i(1)\right]$. Again, the former is strictly bigger than the latter because $\gamma^i(\varnothing) \geq \gamma^i(1)$. ■

Proof of Lemma 2

Proof. To show this, we compare the cost threshold in monopoly and duopoly shutting down the preemption concerns, i.e. assuming $v = 0$. We want to show that in this case $c_D > c_M$. This would require

$$\frac{1}{2}\left[(\gamma(\varnothing) - \gamma(1))\left(\sigma - (2-\sigma)\pi^2\right) + 1\right] > (1-\pi)(\gamma(R) - \gamma(W)) \tag{A.10}$$

Observe that $\gamma(1) = \gamma(W) = \frac{1-\sigma}{2-\sigma}$. Moreover, define $\gamma(\varnothing) - \gamma(1) := A$. We can now rearrange equation (A.10) so that it becomes

$$\frac{1}{2}\left[A\sigma + 1\right] > (1-\pi)(\gamma_R - X) + \frac{1}{2}A(2-\sigma)\pi^2 \tag{A.11}$$

Now, after the relevant substitutions A can be simplified as $A = \frac{\sigma^2}{(2-\sigma)(\sigma^2+(2-\sigma)^2\pi^2)}$. As a consequence,

$$\frac{\partial A}{\partial \sigma} = \frac{2\sigma(2-\sigma)(\sigma^2 + (2-\sigma)^2\pi^2) - \sigma^2(\sigma^2 + 3(2-\sigma)^2\pi^2 - 2\sigma(2-\sigma))}{((2-\sigma)(\sigma^2 + (2-\sigma)^2\pi^2))^2} \tag{A.12}$$

Signing (A.12) is not easy in its current form. However, it is clear that $lim_{\sigma\to 0}\frac{\partial A}{\partial \sigma} = 0$. Moreover, we can rearrange A in a more tractable way. In particular, $A = \frac{1}{(2-\sigma)(1+\pi^2 B^2)}$ where $B = \frac{2-\sigma}{\sigma}$. Since $B > 0$ and $\frac{\partial B}{\partial \sigma} = -\frac{2}{\sigma^2} < 0$, it is now easy to see that

$$\frac{\partial A}{\partial \sigma} = \frac{1 + \pi^2 B - 2\pi^2 B\frac{\partial B}{\partial \sigma}(2-\sigma)}{((2-\sigma)(1+\pi^2 B^2))^2} > 0.$$

The sign of $\frac{\partial^2 A}{\partial \sigma^2}$ is even more complicated, but as A is defined over just two parameters, $\sigma \in [0, 1]$ and $\pi \in (0.5, 1]$, we can prove graphically that $\frac{\partial^2 A}{\partial \sigma^2} > 0$. In particular, Figure A1 shows that $\frac{\partial^2 A}{\partial \sigma^2}$ (the orange plane) is always strictly above the zero (blue plane) for the entire set of relevant parameters.

It is now straightforward to see that in equation (A.11) $\frac{\partial \text{LHS}}{\partial \sigma} > 0$ and $\frac{\partial^2 \text{LHS}}{\partial \sigma^2} > 0$ so the LHS is strictly increasing and convex. Moreover, $\frac{\partial RHS}{\partial \sigma} > 0$.

To complete the proof, we show that LHS($\sigma = 0$) >RHS($\sigma = 1$) for all $\pi \in (0.5, 1)$. This requires

$$\frac{1}{2} > \frac{1-\pi}{1+\pi} + \frac{1}{2}\frac{\pi^2}{1+\pi^2}$$

which further simplifies to

$$1 - 3\pi + 2\pi^2 - 2\pi^3 < 0$$

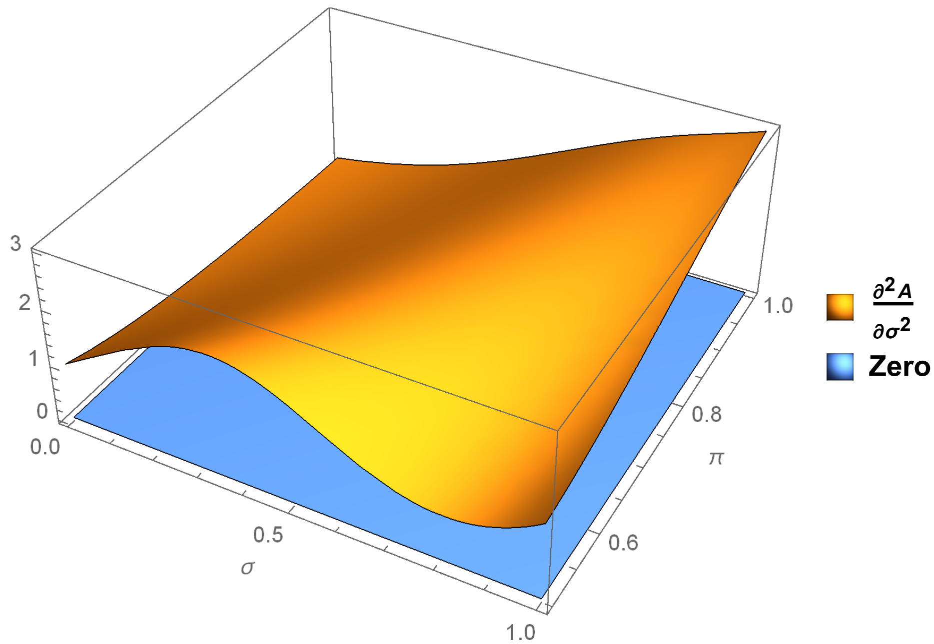

Figure A1: Proof of Lemma 2: Proving $\frac{\partial^2 A}{\partial \sigma^2} > 0$. Orange plane: $\frac{\partial^2 A}{\partial \sigma^2}$, blue plane: $0.\sigma + 0.\pi$ in $\pi - \sigma$ space.

Noticing that the LHS of the above is strictly decreasing in π, and it remains negative for both $\pi = \frac{1}{2}$ and $\pi = 1$, completes the proof. ■

Proof of Proposition 5

Proof. This follows directly from the strict inequality of equation (A.10) and the fact that v only reduces its LHS, without affecting the RHS. ■

Proof of Corollary 1

Proof. The behavior of the monopolist is unchanged with respect to Section 3.1. Looking at the duopoly case, by Bayes' rule

$$\gamma^i(R,.) = \frac{(1-\sigma^i)\pi + \sigma^i}{(1-\sigma^i)\pi + \sigma^i + \pi} = \gamma^i(R)$$

$$\gamma^i(W,.) = \frac{1-\sigma^i}{2-\sigma^i} = \gamma^i(W)$$

Therefore, the cost threshold for research is given by

$$\frac{1}{2}\left[\sigma^j\left(\frac{v}{2}+\gamma^i(R)\right)+(1-\sigma^j)\gamma^i(R)\right]+\frac{1}{2}\gamma^i(R)-c\geq$$
$$\frac{1}{2}\left[\sigma^j\left(v+\pi\gamma^i(R)+(1-\pi)\gamma^i(W)\right)+(1-\sigma^j)\left(\frac{v}{2}+\pi\gamma^i(R)+(1-\pi)\gamma^i(W)\right)\right]+\frac{1}{2}\left(\frac{v}{2}+\pi\gamma^i(R)+(1-\pi)\gamma^i(W)\right),$$

which simplifies to

$$c\leq(1-\pi)(\gamma^i(R)-\gamma^i(W))-\frac{1}{2}v:=c'_D \tag{A.13}$$

Note that the first part of (A.13) is the same as c_M, and the only term that changes is $-\frac{1}{2}v$, making it smaller than c_M.

In terms of existence and uniqueness of the equilibrium in this set up, note that σ^{i*} and σ^{j*} are the solution of the same fixed point problem, i.e.

$$\sigma^*=F(c'_D(\sigma^*))$$

where $c'_D=c_M-\frac{1}{2}v$. The same logic of the proof of Proposition 2 applies here as well. Hence the equilibrium exists and it is unique and symmetric. ■

Proof of Corollary 2

Proof. Consider first the case of monopoly. Here, only the high quality outlet can publish in period 2, and this is observable. As a consequence,

$$\gamma(2)=1$$
$$\gamma(1)=\frac{1-\sigma}{2-\sigma}$$

The monopolist chooses to investigate when $c\leq 1-\gamma(1):=c''_M$.

In duopoly, the beliefs are updated the same way. Each outlet is considered independently and only the timing matters. The threshold is, therefore, given by

$$\frac{1}{2}\left[\sigma^j\left(\frac{v}{2}+1\right)+(1-\sigma^j)\right]+\frac{1}{2}-c\geq\frac{1}{2}\left[\sigma^j\left(v+\gamma^i(1)\right)+(1-\sigma^j)\left(\frac{v}{2}+\gamma^i(1)\right)\right]+\frac{1}{2}\left(\frac{v}{2}+\gamma^i(1)\right).$$

It follows then that $c''_D=1-\gamma^i(1)-\frac{1}{2}v=c''_M-\frac{1}{2}v<c''_M$ as claimed.

In terms of existence and uniqueness, note that σ^* is the solution of

$$\sigma^* = F(c''(\sigma^*))$$

The RHS is continuous on the $[0,1]$ interval and, irrespective of the market structure, it is either strictly increasing and convex or flat. Moreover, RHS($\sigma^* = 0$) $\geq$LHS($\sigma^* = 0$) and RHS($\sigma^* = 1$) $<$ 1 =LHS($\sigma^* = 1$) since $\bar{c} > 1$. ■

Proof of Proposition 6

Proof. We proceed in steps as outlined in Proposition 4. We drop the bars from σ for convenience.

Step 1: We begin by showing that in any signal-based equilibria outlets' period 1 decision on whether to research or publish is described by a threshold on c. This follows from the discussion in the text. Let σ^i and σ^j be the conjectured strategies. Then equation (2) defines the threshold c_D^i for outlet i.

$$c^i \leq \frac{1}{2}\left[\left(\gamma^i(\varnothing) - \gamma^i(1)\right)(\sigma^j - (2-\sigma^j)\pi^2) + (2-\sigma^j)\left(1-\gamma^i(1)\right) - \sigma^j(1-u)\right] + 1 - \frac{3}{2}u := \bar{c}_D^i \quad (2)$$

where $\gamma(\varnothing) = \frac{\sigma^i\sigma^j + (1-\sigma^i)(2-\sigma^j)\pi^2}{\sigma^i\sigma^j + (2-\sigma^i)(2-\sigma^j)\pi^2}$ and $\gamma(1) = \frac{1-\sigma^i}{2-\sigma^i}$. The problem is identical for player j.

Step 2: Next, we show that for any σ^j there is only one σ^i that solves the equilibrium fixed point for player i.

All of the definitions from Proposition 4 remain unaltered.

We want to show that, for every σ^j, there is only one σ^i that solves $\sigma^i = F(\bar{c}_D^i(\sigma^i, \sigma^j))$.

1. The LHS is linear, with slope equal to 1, starting at 0 and ending at 1.

2. Now, $\bar{c}_D^i(\sigma^i = 1, \sigma^j) = c_D^i(\sigma^i = 1, \sigma^j, v = 0) + (1-u)(1 - \frac{\sigma^j}{2})$, where each term is less than or equal to 1. But since $\bar{c} \geq 2.5$, therefore $\bar{c}_D^i(\sigma^i = 1, \sigma^j) < \bar{c}$. As a result, the RHS evaluated at $\sigma^i = 1 < 1 =$ LHS at $\sigma^i = 1$;

3. The RHS evaluated at $\sigma^i = 0$ is greater than or equal to zero.

4. For any σ^j, both LHS and RHS are continuous in σ^i.

Hence, they cross at least once and there is at least one solution to this fixed point problem.

Further, note that $\bar{c}_D^i$ behaves the same way as c_D^i with respect to σ^i. Therefore, the rest of the proof in this step is as before.

Step 3: Third, we show that if an equilibrium exists, it is unique for $\bar{c} \geq 2.5$.

Other than changing the relevant definitions to include σ, nothing changes in this step until we evaluate $\frac{\partial \bar{c}_D^i}{\partial \sigma^j}$

$$\frac{\partial \bar{c}_D^i}{\partial \sigma^j} = \frac{1}{2}\left[\frac{\partial \gamma^i(\varnothing)}{\partial \sigma^j}(\sigma^j - (2-\sigma^j)\pi^2) + \gamma^i(\varnothing) + \pi^2(\gamma^i(\varnothing) - \gamma^i(1)) - (2-u)\right]. \tag{A.14}$$

Again, the rest of the proof remains unaltered until we find the first sufficient condition. The lowest value of the numerator of $\frac{\partial \sigma^i}{\partial \sigma^j}$ from (A.6) can be found by making the relevant replacement from above to (A.14). Therefore,

$$min_{\sigma^i,\sigma^j}\frac{\partial F(\bar{c}_D^i)}{\partial \sigma^j} \geq \frac{1}{\bar{c}+\varepsilon}\frac{1}{2}\left[\frac{1}{2\pi^2}(-2\pi^2) - (2-u)\right] = \frac{-1}{\bar{c}+\varepsilon}\left(\frac{3-u}{2}\right).$$

Therefore, our new first sufficient condition for the uniqueness of the equilibrium is

$$\frac{-\frac{1}{\bar{c}+\varepsilon}\left(\frac{3-u}{2}\right)}{1-\frac{1}{\bar{c}+\varepsilon}} > -1,$$

which simplifies to $\bar{c} \geq \frac{5-u}{2}$. The highest value possible of $\frac{5-u}{2}$ is 2.5 at $u = 0$, which is assumed.

Looking now at the upper bound, again by replacing in (A.14) we get

$$max_{\sigma^i,\sigma^j}\frac{\partial F(\bar{c}_D^i)}{\partial \sigma^i} \leq \frac{1}{\bar{c}+\varepsilon}\frac{1}{2}\left[\frac{1}{2\pi^2}(1-\pi^2) + 1 + \pi^2 - 2 + u\right] = \frac{1}{2(\bar{c}+\varepsilon)}\left[\frac{1}{2\pi^2} + \pi^2 - \frac{3}{2} + u\right].$$

Therefore, our second new sufficient condition for the uniqueness of the equilibrium is

$$\frac{\frac{1}{2(\bar{c}+\varepsilon)}\left[\frac{1}{2\pi^2} + \pi^2 - \frac{3}{2} + u\right]}{1-\frac{1}{\bar{c}+\varepsilon}} < 1$$

The numerator is maximised at $\pi = \frac{1}{\sqrt{2}}$, hence the condition simplifies to $\bar{c}+\varepsilon > \frac{u+2}{2}$. Again, this is satisfied for $\bar{c} \geq 2.5$ since $\frac{5-u}{2} > \frac{u+2}{2}$ for $u \in [0,1]$.

Step 4: Fourth, we show that a symmetric equilibrium where $\sigma^{i*} = \sigma^{j*} = \sigma^*$ always exists. Therefore, it is also unique among the set of signal-based equilibria.

Because of symmetry, the equilibrium must be the fixed point of

$$\sigma^i = \sigma^j = \sigma^* = F(c_D(\sigma^*)) \tag{A.15}$$

where from (2)

$$c_D(\sigma^*) = \frac{1}{2}\left[\left(\frac{(\sigma^*)^2 + (1-\sigma^*)(2-\sigma^*)\pi^2}{(\sigma^*)^2 + (2-\sigma^*)^2\pi^2} - \frac{1-\sigma^*}{2-\sigma^*}\right)(\sigma^* - (2-\sigma^*)\pi^2) - \sigma^*(1-u)\right] - \frac{3}{2}(1-u) \tag{A.16}$$

Looking at (A.15), note that both LHS and RHS are continuous on the $[0,1]$ interval. Moreover, RHS$(\sigma^* = 0) \geq 0 =$ LHS(σ^*) and RHS$(\sigma^* = 1) < 1 =$LHS$(\sigma^* = 1)$. As a consequence, there exists a solution in the $[0,1]$ interval. From the previous steps, we know that this solution is unique.

Step 5: Finally, we show that in the symmetric equilibrium it is optimal to endorse the state suggested by the most informative signal.

This is true because now there is more incentive to build a reputation. Since reputation requires matching the state, there is even less reason to not endorse the state suggested by the most informative equilibrium. ■

Proof of Proposition 7

Proof. We drop the bars for convenience. First, note that $\bar{c}_D$ is decreasing in u. This is so because it can be rearranged as

$$\bar{c}_D = \frac{1}{2}\left[(\gamma(\varnothing) - \gamma(1))(\sigma^* - (2-\sigma^*)\pi^2) - \sigma^*\right] + \frac{3}{2} - u\left(\frac{3}{2} - \frac{\sigma^*}{2}\right)$$

where $\frac{3}{2} - \frac{\sigma^*}{2} > 0$ for any $\sigma^* \in [0,1]$. Also, c_M and σ^*_M do not change with u.

Second, consider the case when $u = 1$. We will show that $\bar{c}_D < c_M$. This requires

$$\frac{1}{2}\left[(\gamma(\varnothing) - \gamma(1))(\sigma - (2-\sigma)\pi^2)\right] < (1-\pi)(\gamma(R) - \gamma(W)).$$

Using the terminology introduced in Lemma 2, we can rewrite the above as

$$\frac{1}{2}A\sigma < (1-\pi)(\gamma(R) - \gamma(W)) + \frac{1}{2}A(2-\sigma)\pi^2.$$

Now, both the LHS and the RHS of the above equation are only functions of two variables, π and σ, which are defined on compact and continuous sets. Therefore, we can plot them in a graph (see Figure A2) and check that the above is true.

Third, consider the case of $u = 0$. We want to show that $\bar{c}_D > c_M$. This is equivalent to showing

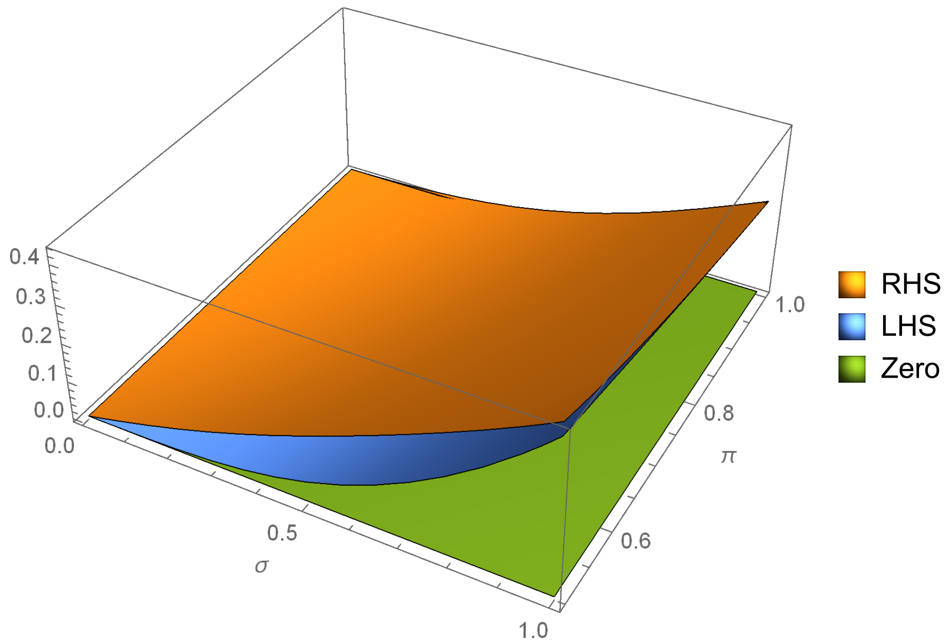

Figure A2: Proof of Proposition 7: Proving LHS < RHS. Orange plane: RHS, blue plane: LHS and green plane: $0.\sigma + 0.\pi$ in the $\pi - \sigma$ space.

that

$$\frac{1}{2}\left[(\gamma(\varnothing) - \gamma(1))(\sigma - (2-\sigma)\pi^2) - \sigma\right] + \frac{3}{2} > (1-\pi)(\gamma(R) - \gamma(W)).$$

We showed in Lemma 2 that $c_D(v=0) > c_M$. It is easy to check that $\bar{c}_D(u=0) = c_D(v=0) + 1 - \frac{1}{2}\sigma$ where $1 - \frac{1}{2}\sigma > 0$ for all $\sigma \in [0,1]$. Therefore, $\bar{c}_D(u=0) > c_D(v=0) > c_M$.

Combining the three parts above, our result follows. ■

Proof of Proposition 8

Proof. We drop the bars and stars for convenience. Reminding ourselves that

$$V = \frac{(4-\sigma^2)}{4}\pi u + \frac{1}{2}\sigma(2-\sigma)(1-u) + \frac{1}{4}(1-(1-\sigma)^2)u,$$

we first take the first derivative of V with respect to π (we drop the stars and D in what follows for convenience).

$$\begin{aligned}\frac{\partial V}{\partial \pi} &= u\frac{(4-\sigma^2)}{4} + \left[\pi u\frac{(-2\sigma)}{2} + \frac{1}{2}(1-u)2(1-\sigma) + u\frac{(1-\sigma)}{2}\right]\frac{\partial \sigma}{\partial \pi} \\ &= u\frac{(4-\sigma^2)}{4} + \frac{2(1-\sigma) - u(1-\sigma(1-\pi))}{2}\frac{\partial \sigma}{\partial \pi} \qquad \text{(A.17)}\end{aligned}$$

Now, we need to show under what conditions $\frac{\partial \sigma}{\partial \pi} < 0$. Reminding that σ is implicitly defined by (A.15) define

$$K := \sigma - \left[\frac{1}{2}\left[\left(\gamma(\varnothing) - \gamma(1)\right)\left(\sigma - (2-\sigma)\pi^2\right) - \sigma(1-u)\right] + \frac{3}{2}(1-u)\right]\frac{1}{\bar{c}+\varepsilon} - \frac{\varepsilon}{\bar{c}+\varepsilon}$$

Further, using the definitions in the proof of Lemma 2, we can rewrite K as

$$K = \sigma - \frac{1}{2(\bar{c}+\varepsilon)}\left[A(\sigma - (2-\sigma)\pi^2) - \sigma(1-u)\right] - \frac{3}{2(\bar{c}+\varepsilon)}(1-u) - \frac{\varepsilon}{\bar{c}+\varepsilon}$$

Differentiating and simplifying, we first obtain

$$\begin{aligned}\frac{\partial K}{\partial \pi} &= -\frac{1}{2(\bar{c}+\varepsilon)}\left[\frac{-2\pi B^2(\sigma-(2-\sigma)\pi^2)}{(2-\sigma)(1+\pi^2B^2)^2} - \frac{2\pi}{1+\pi^2B^2}\right] \\ &= \frac{1}{2(\bar{c}+\varepsilon)}\frac{1+B}{(1+\pi^2B^2)^2} > 0,\end{aligned}$$

and second we obtain

$$\begin{aligned}\frac{\partial K}{\partial \sigma} &= 1 - \frac{1}{2(\bar{c}+\varepsilon)}\left[\frac{\partial A}{\partial \sigma}(\sigma-(2-\sigma)\pi^2) + (1+\pi^2)A - (1-u)\right] \\ &= 1 + \frac{1}{2(\bar{c}+\varepsilon)}(1-u) - \frac{1}{2(\bar{c}+\varepsilon)}\left[\frac{\partial A}{\partial \sigma}(\sigma-(2-\sigma)\pi^2) + (1+\pi^2)A\right] \\ &= 1 + \frac{1}{2(\bar{c}+\varepsilon)}(1-u) - \frac{1}{\bar{c}+\varepsilon}\frac{\partial c_D}{\partial \sigma}\end{aligned}$$

where c_D is the cost threshold we derived in Proposition 4.

We can now show that $\frac{\partial c_D}{\partial \sigma} \leq 1$ in the neighborhood of the equilibrium σ. The proof for this is presented in Proposition 12 (Appendix C) for a generic prior q. Therefore, it is also true in our special case of $q = \frac{1}{2}$.

Putting these two facts together and using the Implicit Function Theorem, we can now conclude that $\frac{\partial \sigma}{\partial \pi} < 0$.

Finally, we want to find the condition under which $\frac{\partial V}{\partial \pi} < 0$. From (A.17), this happens when

$$u\frac{(4-\sigma^2)}{4} < \frac{2(1-\sigma) - u(1-\sigma(1-\pi))}{2}\sigma_\pi,$$

where $\left(-\frac{\partial \sigma}{\partial \pi}\right) := \sigma_\pi > 0$. Now, the LHS of the above equation is linearly increasing in u. Similarly, the RHS is linearly decreasing in u. In addition, for $u = 0$, LHS < RHS and the condition is verified. And for $u = 1$, LHS > RHS. To see this, LHS$(u=1) = 2 - \frac{\sigma^2}{2} > 1$, while RHS$(u=1) = (1-\sigma(1+\pi))\sigma_\pi < 1$.

Therefore, $\bar{u}^V$ exists and lies between 0 and 1. ■

Proof of Lemma 3

Proof. Comparing the source's expected utility given by expressions in (3) and (4) and simplifying gives the following condition to prefer two firms:

$$\mu(1-\pi)(2\sigma_M - \sigma_D(4-\sigma_D)) \leq 2\sigma_M - \sigma_D^2 \tag{A.18}$$

Now we discuss different cases based on possible values of σ_M and σ_D.

Case 1: v is very high so that $\sigma_D = 0$. Substituting in A.18 gives that the source prefers to send the story to both outlets if

$$\mu \leq \frac{1}{1-\pi} > 1$$

Therefore, if v is very large it is possible that $\mu > 1$ (so that the source cares relatively more about matching the state) and $\sigma_D = 0$ (so that in duopoly no one does research), but still the source prefers to share information with both the outlets. This happens because $\pi > .5$ and the source still cares about getting the information out quickly.

Case 2: v is high enough so that $\sigma_D < \sigma_M$. Now, the RHS of equation (A.18) is greater than zero. But first, σ_D might not be too small so that in the LHS < 0 i.e. $2\sigma_M \leq \sigma_D(4-\sigma_D)$. In this case, sending to both is always preferred independent of μ. Therefore, sending to both is preferred if

$$\sigma_D < \sigma_M \leq \frac{\sigma_D(4-\sigma_D)}{2}.$$

Second, σ_D might in fact be very small so that on the LHS > 0 i.e. $2\sigma_M > \sigma_D(4-\sigma_D)$. In this case, sending to both is preferred only if

$$\mu \leq \frac{2\sigma_M - \sigma_D^2}{2\sigma_M - \sigma_D(4-\sigma_D)} \frac{1}{(1-\pi)}.$$

Case 3: v is small so that $\sigma_D > \sigma_M$. Again there are two possible situations. First, consider the case in which σ_D is not too large so that the RHS of equation (A.18) is still positive, i.e. $2\sigma_M \geq \sigma_D^2 \implies \sigma_M \geq \frac{\sigma_D^2}{2}$. Now, in this case we want to see whether the LHS can be negative i.e. if $\sigma_M < \frac{\sigma_D(4-\sigma_D)}{2}$. But this must be true because $\sigma_D > \sigma_M$ and we know that $\frac{\sigma_D(4-\sigma_D)}{2} > \sigma_D$. Therefore, the LHS is negative and the RHS is positive, so the condition outlined in (A.18) is satisfied. Sending to both is always preferred if

$$\frac{\sigma_D^2}{2} \leq \sigma_M < \sigma_D.$$

Second, σ_D might in fact be very large so that the RHS is negative, i.e. $\sigma_M < \frac{\sigma_D^2}{2}$. Now, it cannot be that the LHS is positive because that requires $\sigma_M > \frac{\sigma_D(4-\sigma_D)}{2}$ which contradicts $\sigma_M < \sigma_D$. Therefore, LHS must also be negative. From condition (A.18), the source prefers both outlets only if

$$\mu \geq \frac{\sigma_D^2 - 2\sigma_M}{\sigma_D(4-\sigma_D) - 2\sigma_M}\frac{1}{(1-\pi)}.$$

Case 4: v is such that $\sigma_D = \sigma_M := \sigma$. When this is the case, the condition (A.18) reduces to

$$-\mu(1-\pi)(2-\sigma) < (2-\sigma)$$

which is always true. Therefore, sending to both is preferred.

Our result follows from combining all the above cases. ∎

Proof of Proposition 9

Proof. The proof is by construction. We have already constructed the equilibrium frontier and the set of all possible equilibria for a given $\bar{c}$ and ε.

We now show what happens as $\varepsilon \to 0$. Consider σ_M first. From Proposition 2, observe that as $\varepsilon \to 0$ LHS$(\sigma = 0) = 0 \approx$ RHS$(\sigma = 0) = \frac{\varepsilon}{\bar{c}+\varepsilon} \to 0$ in equation (A.3). Therefore, for any π the only fixed point equilibrium $\to 0$.

Now, consider σ_D at $v = 0$. Fix a π. We know that as $\varepsilon \to 0$, since $c_D(\sigma = 0) = \frac{1}{2}$, we have that RHS$(\sigma = 0) \to \frac{1}{2\bar{c}}$ in equation (A.9). But this is strictly greater than LHS$(\sigma = 0) = 0$. Therefore, the equilibrium fixed point $\sigma_D > 0$ and also $\frac{\sigma_D^2}{2} > 0$. Moreover, this is true for any π.

Therefore, in the $\sigma_D - \sigma_M$ space as $\varepsilon \to 0$, the equilibrium frontier lies below the $\sigma_M = \frac{\sigma_D^2}{2}$ line.

Now, let us look at what happens as $\varepsilon \to \infty$. Given that the fixed point is defined by $\sigma^* = \frac{c^*+\varepsilon}{\bar{c}+\varepsilon}$, both σ_M and σ_D approach 1 (without ever being exactly equal to 1). However, because the frontier is defined for $v = 0$ case, the frontier lies close to and to the right of the $\sigma_M = \sigma_D$ line.

Combining the two observations above with Lemma 3, we get our proposition. ∎

B Allowing for sitting on information

In this appendix, we show that allowing outlets to "sit on information" (i.e. just refrain from publishing until period 2 without acquiring the additional signal) does not preclude the equilibrium outlined in Proposition 4. We prove it formally for sufficiently low π and then use mathematical simulation to argue that it holds more generally. Uniqueness of such an equilibrium (among signal-based equilibria), however, is not obvious anymore. We make only one change with respect to the model described in Section 2. Now $d^i \in \{res, pub, wait\}$, where $d^i = wait$ means that the outlet does not acquire the second signal but still publishes in period 2.

This addition poses some challenges in the tractability of the model because the choice is no longer just between two options and strategies are not necessarily just thresholds in c. However, even in this more complicated setup we can show a few results. First, for sufficiently low π, it is possible to find values of v such that the equilibrium described in Proposition 4 exists; waiting is never a best response if the other player never waits and $\sigma_D^* > \sigma_M^*$. Second, we can simulate the model showing that we can assign values to v such that, for the resulting equilibrium σ_D^*, publishing in period 1 is better than waiting and at the same time $\sigma_D^* > \sigma_M^*$.

We begin with the following lemma considering that we are interested in the (candidate) equilibrium strategies described in Proposition 4 where $d^i = wait$ is never played in equilibrium.

Lemma 4 *It is always possible to find off path beliefs such that, for sufficiently high v, $Eu^i(d^i = wait) \leq Eu^i(d^i = pub)$.*

Proof. Note that $\gamma(W_{\text{II}}, .)$ is off path in the equilibrium we are considering. For any $\gamma(\varnothing)$ and $\gamma(1)$ as defined above, the expected utility from choosing $d^i = wait$ is

$$\frac{1}{2}\sigma^j \left(\frac{v}{2} + \pi\gamma(\varnothing) + (1-\pi)\gamma(1)\right) + \left(\frac{1}{2}(1-\sigma^j) + \frac{1}{2}\right)(\pi + (1-\pi)\gamma(W_{\text{II}}, .)) \tag{B.19}$$

On the other hand, the expected utility from publishing immediately is given by

$$\frac{1}{2}\sigma^j (v + \gamma(1)) + \left(\frac{1}{2}(1-\sigma^j) + \frac{1}{2}\right)(\frac{v}{2} + \pi^2(\gamma(\varnothing) - \gamma(1)) + \gamma(1)) \tag{B.20}$$

Comparing (B.19) and (B.20) and solving for v, we find that $Eu^i(d^i = wait) \leq Eu^i(d^i = pub)$ when

$$v \geq \sigma^j \pi(\gamma(\varnothing) - \gamma(1)) - (2-\sigma^j)\left[\pi^2\gamma(\varnothing) + (1-\pi^2)\gamma(1) - \pi - (1-\pi)\gamma(W_{\text{II}}, .)\right] \tag{B.21}$$

Therefore, it is possible to find v and $\gamma(W_{\text{II}}, .)$ such that the above condition is satisfied. ■

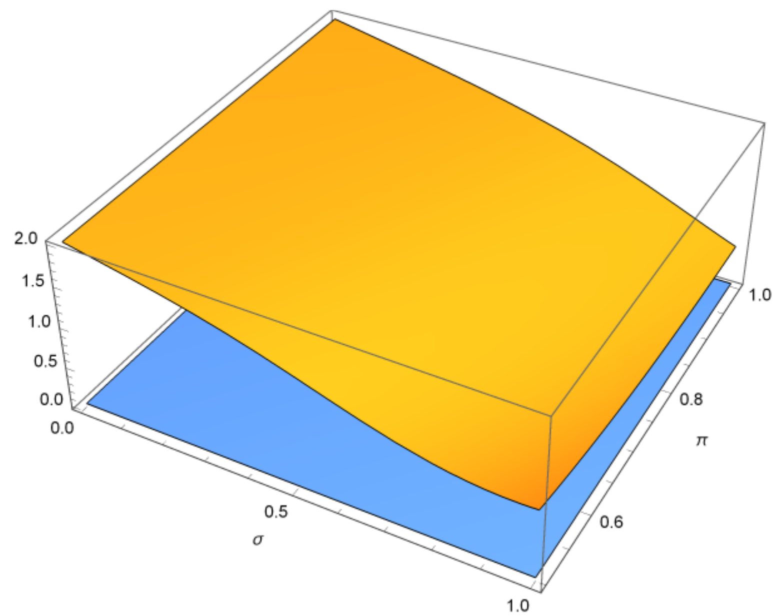

Figure B3: Proof of Proposition 10: Proving $\frac{\partial \bar{v}}{\partial \pi} > 0$. Orange plane: $\frac{\partial \bar{v}}{\partial \pi}$, blue plane: $0.\sigma + 0.\pi$ in the $\pi - \sigma$ space.

This makes intuitive sense as a sufficiently high scoop value should always deter sitting on information. From now on, we set $\gamma(W_{\mathrm{II}}, .) = 0$ and we define $\bar{v} := \sigma^j \pi(\gamma(\varnothing) - \gamma(1)) - (2 - \sigma^j)\left[\pi^2\gamma(\varnothing) + (1 - \pi^2)\gamma(1) - \pi\right]$.

We can now move to the main proposition.

Proposition 10 *For sufficiently low π, it is possible to find values of v such that the equilibrium described in Proposition 4 exists. In such an equilibrium, waiting is never a best response if the other player follows the equilibrium strategies and $\sigma_D^* > \sigma_M^*$.*

Proof. Suppose that player j always publishes when low type and chooses just between publishing or researching when high type. Moreover, suppose that the audience conjectures that both players use the equilibrium strategies described by Proposition 4. For this to be an equilibrium in the new setup, it is sufficient to prove that, given the correct audience's beliefs updating, for every σ, $Eu^i(d^i = wait) \leq Eu^i(d^i = pub)$. To show this, first we prove through Figure B3 that $\frac{\partial \bar{v}}{\partial \pi} > 0$. Moreover, Figure B4 shows that there exists a range of π such that $argmax_\sigma \bar{v}(\pi) = 1$. In the figure, it happens for $\pi \in [.5, .6]$. As a consequence, for every $v \geq \bar{v}(\sigma = 1, \pi \in [0.5, 0.6])$ it is true that, for every

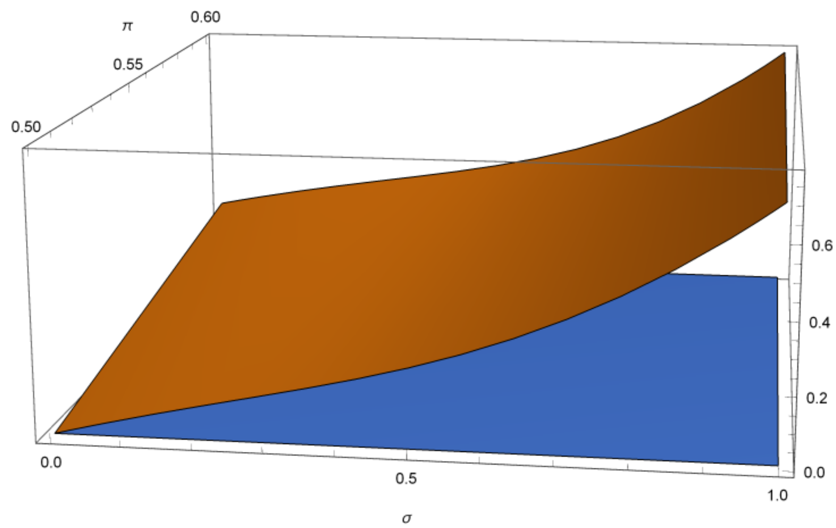

Figure B4: Proof of Proposition 10: Proving $argmax_\sigma \bar{v}(\pi) = 1$. Orange plane: $\bar{v}(\pi)$, blue plane: $0.\sigma + 0.\pi$ in the $\pi - \sigma$ space for $\pi \in [0.5, 0.6]$.

σ, $Eu^i(d^i = wait) \leq Eu^i(d^i = pub)$. In other words, if the audience conjectures an equilibrium where no types and no players choose to wait and the choice for the high type is just between publishing and researching described by a threshold strategy on c, behaving in this way is an equilibrium strategy for the outlets.

Finally, Figure B5 plots c_M and $c_D(\bar{v}(\sigma = 1))$ for sufficiently small π, proving that we can still increase v from $\bar{v}(\sigma)$ maintaining the necessary condition for $\sigma_D^* > \sigma_M^*$, i.e. $c_D \geq c_M$. ■

When $\pi > 0.6$, we can show the existence of our candidate equilibrium through mathematical simulations. Consider for example the following set of parameters: $\pi = 0.75$, $v = 0.7$, $\bar{c} = 2$, $\varepsilon = 0.1$. In this case, the equilibrium described in Proposition 4 (assuming it still exists) gives a solution $\sigma_D^* = 0.118219$.[25] Suppose now that player i expects player j to never wait and choose to research (if it is high type) with probability 0.118219. Further, suppose the audience think that both outlets never wait and research (if they are high types) with probability 0.118219. In this case, $Eu^i(d^i = wait) = 0.754218$ and $Eu^i(d^i = pub) = 0.841236$. Hence, there is no incentive to choose waiting instead of publishing, and the meaningful choice is just between researching and publishing. The solution to this problem is the same as that described by Proposition 4. Finally, Figure B6 shows that, for $\pi = 0.75$ and $v = 0.7$, it is still true that $c_D \geq c_M$ for every σ. More generally, Figure B7 plots c_M and c_D (in the $\pi - \sigma$

[25]We simulated the model with Mathematica. The code is available upon request.

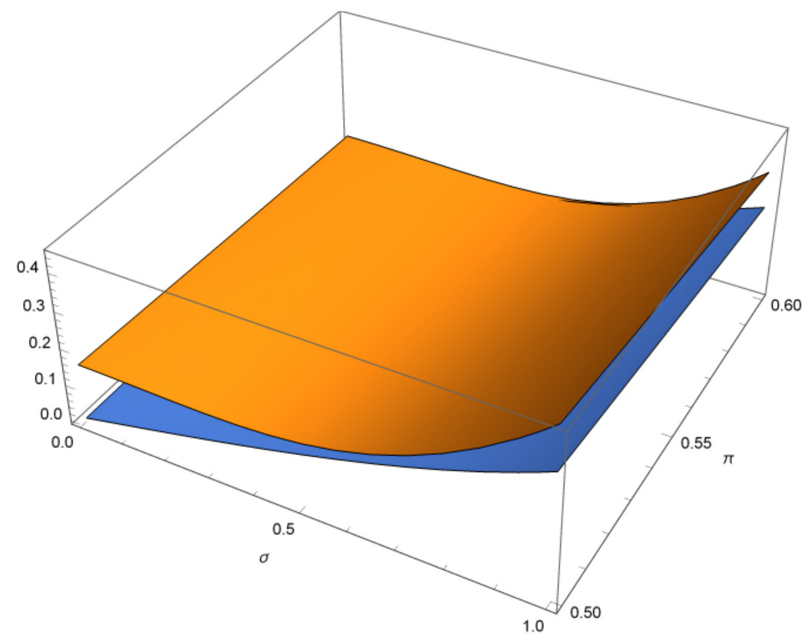

Figure B5: Proof of Proposition 10: Proving $c_D(\bar{v}(\sigma = 1)) > c_M$. Orange plane: $c_D(\bar{v}(\sigma = 1))$, blue plane: c_M in the $\pi - \sigma$ space for $\pi \in [0.5, 0.6]$.

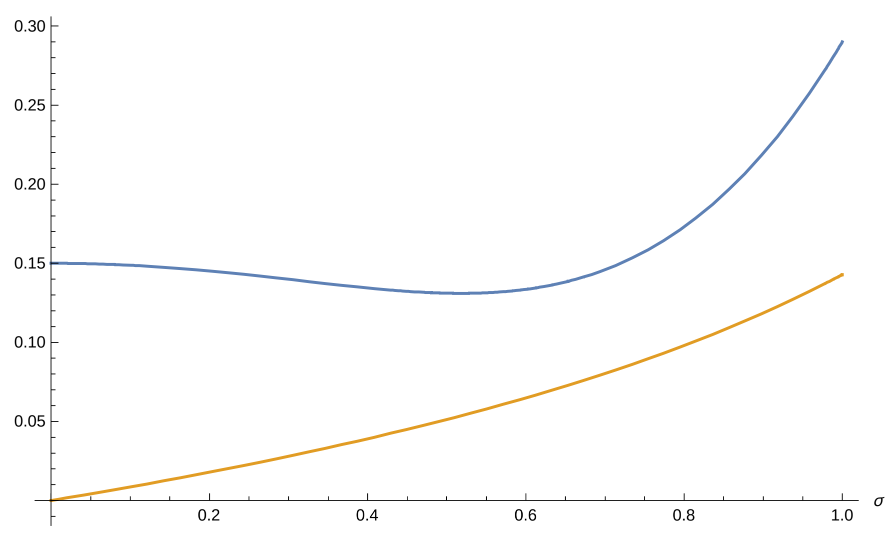

Figure B6: $c_D > c_M$ for $\pi = 0.75$ and $v = 0.7$. Orange line: c_M, blue line: c_D as a function of σ)

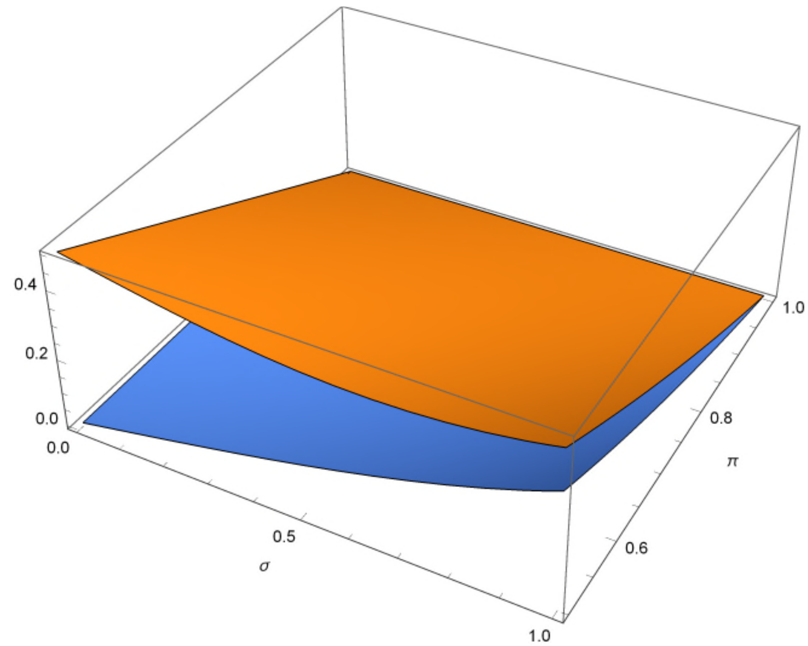

Figure B7: $c_D(v = \bar{v} > c_M$ for every combination of σ and π. Orange plane: $c_D(v = \bar{v})$, blue plane: c_M in the $\pi - \sigma$ space.

space) by replacing v with the corresponding $\bar{v}$. Still, c_D is above c_M throughout the entire range of parameters of our model.

C Generic prior on the type

This appendix shows that our main results are qualitatively unaffected by the assumption of prior $\Pr(\theta^i = h) = \frac{1}{2}$. In this section, we assume a generic prior $\Pr(\theta^i = h) = q \in (0,1)$, leaving the rest of the model unchanged. We consider monopoly, duopoly and their comparison for when θ is unknown to the reader.

Monopoly

The proposition of the main result is unchanged in monopoly, as q enters only in the readers' beliefs updating.

Proposition 11 *If there is one media outlet and θ is not known to the audience, there exists a unique equilibrium in which the high quality outlet conducts research in $t = 1$ iff*

$$c \leq (1-\pi)(\gamma(R) - \gamma(W)) := c_M$$

where $\gamma(R)$ and $\gamma(W)$ are the audiences' beliefs about the outlet's quality after it gets the state right and wrong respectively. As a consequence, $\sigma^* = F(c_M(q)) = \frac{c_M(q,\sigma^*)+\varepsilon}{\bar{c}+\varepsilon}$.

Proof. Suppose that a high type outlet chooses $d = res$ with probability σ. Reminding ourselves from the main text that by Bayes' rule,

$$\gamma(R) = \frac{q(\sigma + (1-\sigma)\pi)}{q(\sigma + (1-\sigma)\pi) + (1-q)\pi}$$

$$\gamma(W) = \frac{q(1-\sigma)(1-\pi)}{q(1-\sigma)(1-\pi) + (1-q)(1-\pi)} = \frac{q(1-\sigma)}{1-q\sigma}.$$

A high quality optimally chooses res if

$$\gamma(R) - c \geq \pi\gamma(R) + (1-\pi)\gamma(W) \implies c \leq (1-\pi)(\gamma(R) - \gamma(W)) := c_M(q)$$

In equilibrium the conjectured σ must be equal to the actual one, hence it must be that

$$\sigma^* = F(c_M(q, \sigma^*)). \tag{C.22}$$

We need to check if such a fixed point exists. To do so, three observations are in order. First, note that both the LHS and RHS of the above are continuous in σ^*. Second, $\text{LHS}(\sigma^* = 0) = 0 < \text{RHS}(\sigma^* =$

$0) = \frac{\varepsilon}{\bar{c}+\varepsilon}$ (as $c_M(q) = 0$ at $\sigma^* = 0$). Third, LHS$(\sigma^* = 1) = 1 >$ RHS$(\sigma^* = 1) = F\left(\frac{(1-\pi)q}{q+(1-q)\pi}\right)$, so the equilibrium is the solution of $\sigma^* = \frac{c_M(q,\sigma^*)+\varepsilon}{\bar{c}+\varepsilon}$ and LHS and RHS must cross at least once.

Finally, we need to check for the uniqueness of the fixed point. To show this, it is sufficient to prove that the derivative of the RHS with respect to σ is smaller than 1. Note that

$$\frac{\partial \text{RHS}}{\partial \sigma^*} = \frac{1-\pi}{\bar{c}+\varepsilon}\left[\frac{\pi(1-\pi)q(1-q)}{(q(\sigma+(1-\sigma)\pi)+(1-q)\pi)^2} + \frac{q(1-q)}{(1-q\sigma^*)^2}\right] > 0$$

Moreover, we can rewrite the equation as

$$\frac{\partial \text{RHS}}{\partial \sigma^*} = \frac{(1-\pi)q(1-q)}{\bar{c}+\varepsilon}\left[\frac{\pi(1-\pi)}{(q(\sigma+(1-\sigma)\pi)+(1-q)\pi)^2} + \frac{1}{(1-q\sigma^*)^2}\right]$$

It is easy to see that, in the range of parameters of the model, $(1-\pi)q(1-q) \leq \frac{1}{8}$; $\frac{\pi(1-\pi)}{(q(\sigma+(1-\sigma)\pi)+(1-q)\pi)^2} \leq 1$ because $\pi(1-\pi)$ is at most $\frac{1}{4}$ and $q(\sigma+(1-\sigma)\pi)+(1-q)\pi$ is at least $\frac{1}{2}$ (when $\sigma = 0$ and $\pi = \frac{1}{2}$); $\frac{1}{(1-q\sigma^*)^2} \leq 1$. As a consequence,

$$\frac{\partial \text{RHS}}{\partial \sigma^*} < \frac{1}{8}[1+1] < 1$$

and this completes the proof. ■

Duopoly

For the case of duopoly, we look directly at symmetric equilibria, showing that there exists a unique symmetric equilibrium.

Proposition 12 *If there are two media outlets and θ is not known to the audience, there exists a unique symmetric equilibrium where $\sigma^{i*} = \sigma^{j*} := \sigma^* = F(c_D(q))$ such that*

$$c_D(q) = \left[(\gamma(\varnothing) - \gamma(1))\left(q\sigma^* - (1-q\sigma^*)\pi^2\right) + 1 - q\right] - \frac{1}{2}v$$

where $\gamma(\varnothing) = \frac{q((\sigma^*)^2 q + (1-\sigma^*)(1-q\sigma^*)\pi^2)}{(q\sigma^*)^2 + (1-q\sigma^*)^2\pi^2}$ and $\gamma(1) = \frac{q(1-\sigma^*)}{1-q\sigma^*}$.

Proof. We focus directly on symmetric equilibria where each high type outlet uses a threshold strategy on c in the decision on whether to publish or investigate. Define σ as the probability (from the point of view of the other players) that a high quality outlet chooses to do research. For the same logic as in

Proposition 4, the threshold is given by

$$c^i \leq \left[(\gamma(\varnothing) - \gamma(1)) \left(q\sigma - (1 - q\sigma)\pi^2 \right) + (1 - q\sigma)\left(1 - \gamma(1)\right) \right] - \frac{1}{2}v := c_D(q) \tag{1}$$

where, by Bayes' rule, $\gamma(\varnothing) = \frac{q(\sigma^2 q + (1-\sigma)(1-q\sigma)\pi^2)}{q^2\sigma^2 + (1-q\sigma)^2\pi^2}$ and $\gamma(1) = \frac{q(1-\sigma)}{1-q\sigma}$.

Given that cost is uniformly distributed in $[-\varepsilon, \bar{c}]$ and that in equilibrium the conjectured probability of investigation must be equal to the actual one, the (symmetric) equilibrium level of σ, if it exists, must be the solution of

$$\sigma = F(c_D(q, \sigma)) \tag{C.23}$$

where

$$F(c_D(q,\sigma)) = \begin{cases} 0 & c_D(q,\sigma) < -\varepsilon \\ \frac{c_D(q,\sigma)+\varepsilon}{\bar{c}+\varepsilon} & -\varepsilon \leq c_D(q,\sigma) \leq \bar{c} \\ 1 & c_D(q,\sigma) > \bar{c} \end{cases}$$

and

$$f(c_D(q,\sigma)) = \begin{cases} 0 & c_D(q,\sigma) < -\varepsilon \\ \frac{1}{\bar{c}+\varepsilon} & -\varepsilon \leq c_D(q,\sigma) \leq \bar{c} \\ 0 & c_D(q,\sigma) > \bar{c} \end{cases}$$

Note that:

1. The LHS of equation (C.23) is linear, with slope equal to 1, starting at 0 and ending at 1;

2. RHS($\sigma = 0$) ≥ 0 =LHS($\sigma = 0$);

3. RHS($\sigma = 1$) < 1 =LHS($\sigma = 1$);

4. Both LHS and RHS are continuous in σ.

Hence, they cross at least once and there is at least one solution to this fixed point problem.

To show uniqueness, we can rewrite $c_D(q)$ as

$$c_D = AE + 1 - q - \frac{1}{2}v$$

where $A := \gamma(\varnothing) - \gamma(1) = \frac{q^2(1-q)}{(1-q\sigma)[q^2+\pi^2 B^2]}$, $B := \frac{1-q\sigma}{\sigma}$ and $E := q\sigma - (1-q\sigma)\pi^2$. It is easy to see that $\frac{\partial E}{\partial \sigma} \geq 0$. Moreover, it is also true that $\frac{\partial A}{\partial \sigma} \geq 0$. To see this, note that

$$\frac{\partial A}{\partial \sigma} = \frac{-q^2(1-q)\left[-q(q^2+\pi^2 B^2) + 2\pi^2 B \frac{\partial B}{\partial \sigma}(1-\sigma q)\right]}{((1-q\sigma)\left[q^2+\pi^2 B^2\right])^2} \geq 0$$

because $\frac{\partial B}{\partial \sigma} \leq 0$. However, the sign of E is ambiguous, with $E < 0$ for $\sigma < \frac{\pi^2}{q(1+\pi^2)} := \sigma^T$. We claim that the following two conditions are sufficient for uniqueness:

1. $\frac{\partial c_D(q)}{\partial \sigma} \leq 1$ for $\sigma \leq \sigma^T$;

2. $\frac{\partial^2 c_D(q)}{\partial \sigma^2} \geq 0$ for $\sigma \geq \sigma^T$;

The argument is as follows: as RHS($\sigma = 0$) ≥ 0 =LHS($\sigma = 0$) and RHS($\sigma = 1$) < 1 =LHS($\sigma = 1$), the fixed point is:

1. Only at $\sigma = 0$, as RHS($\sigma = 0$) =RHS($\sigma = \sigma^T$) and below that in between. Moreover, there cannot be any additional crossing point above σ^T because the RHS would be coming from below, and, as it is convex, it cannot be that they cross and RHS($\sigma = 1$) < 1 =LHS($\sigma = 1$).

2. If the solution is not at 0, the first time they cross it must be that the LHS comes from below. There are two sub-cases:

   - If the first crossing point is in $\sigma \leq \sigma^T$, then there cannot be others in the same interval as $\frac{\partial c_D(q)}{\partial \sigma} \leq 1$. Moreover, there cannot be any other crossing point above σ^T because the RHS would be coming from below, and, as it is convex, it cannot be that they cross and RHS($\sigma = 1$) < 1 =LHS($\sigma = 1$).

   - If the first crossing point is above σ^T, it must be unique as a second solution would violate RHS($\sigma = 1$) < 1 =LHS($\sigma = 1$).

We now prove that the two sufficient conditions outlined above apply to our model.

First, a sufficient condition for $\frac{\partial c_D(q)}{\partial \sigma} \leq 1$ for $\sigma \leq \sigma^T$ is $\frac{\partial E}{\partial \sigma} A \leq 1$. This implies $(1+\pi^2)q^3(1-q) \leq (1-q\sigma)(q^2+\pi^2 B^2)$. As the RHS is decreasing in σ, this condition must hold for the highest possible σ, i.e. for $\sigma = \sigma^T$. Substituting and simplifying, this requires $q(1-q) \leq \frac{1}{\pi^2(1+\pi^2)}$. The LHS is at most $\frac{1}{4}$ while the RHS is at least $\frac{1}{2}$, hence the condition is always satisfied.

Second, a sufficient condition for convexity of $c_D(q)$ for $\sigma \geq \sigma^T$ is $\frac{\partial^2 A}{\partial \sigma^2} \geq 0$. To show that it is always the case, note that

$$\frac{\partial^2 A}{\partial \sigma^2} = -q^2(1-q)\frac{\frac{\partial^2 D}{\partial \sigma^2} D^2 - 2D\frac{\partial D}{\partial \sigma}^2}{D^4} \tag{C.24}$$

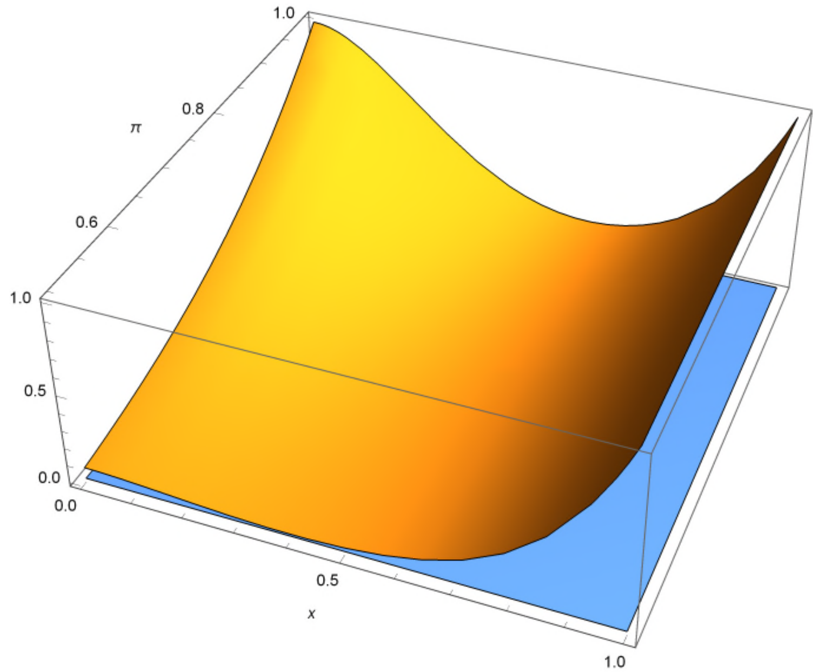

Figure C8: Proof of Proposition 12: Proving LHS > RHS in (C.25). Orange plane: LHS−RHS, blue plane: $0 * x + 0 * \pi$ in the $\pi - x$ space.

where $D = (1 - q\sigma)\left[q^2 + \pi^2 B^2\right]$, $\frac{\partial D}{\partial \sigma} = -q(q^2 + \pi^2 B^2) + \pi^2 2B\frac{\partial B}{\partial \sigma}(1 - \sigma q) < 0$ and $\frac{\partial^2 D}{\partial \sigma^2} = -q\pi^2 2B\frac{\partial B}{\partial \sigma} + 2\pi^2\left[\left(\frac{\partial B}{\partial \sigma}^2 + \frac{\partial^2 B}{\partial \sigma^2}B\right)(1 - \sigma q) - qB\frac{\partial B}{\partial \sigma}\right] > 0$. A sufficient condition for (C.24) to be positive is $2\frac{\partial D}{\partial \sigma}^2 \geq \frac{\partial^2 D}{\partial \sigma^2}D$.

By substitution, this implies

$$
\begin{gathered}
2\left[-q(q^2\sigma^2 + \pi^2(1 - q\sigma)^2)\frac{1}{\sigma^2} - 2\pi^2\frac{(1 - q\sigma)^2}{\sigma^3}\right]^2 \geq \left[q\pi^2 2\sigma\frac{(1 - q\sigma)}{\sigma^4} + 2\pi^2(1 - q\sigma)\frac{1}{\sigma^4} + \frac{4(1 - q\sigma)^2}{\sigma^4}\pi^2 + 2q\pi^2\sigma\frac{(1 - q\sigma)}{\sigma^4}\right](1 - q\sigma)(q^2 + \pi^2 B) \\
\sigma^2\left[-q(q^2\sigma^2 + \pi^2(1 - q\sigma)^2) - 2\pi^2\frac{(1 - q\sigma)^2}{\sigma}\right]^2 \geq 3\pi^2(1 - q\sigma)^2(q^2\sigma^2 + \pi^2(1 - q\sigma)^2) \\
\sigma^2 q^2(q^2\sigma^2 + \pi^2(1 - q\sigma)^2)^2 + 4\pi^4(1 - q\sigma)^4 + 4\pi^2(1 - q\sigma)^2 q\sigma(q^2\sigma^2 + \pi^2(1 - q\sigma)^2) \geq 3\pi^2(q^2\sigma^2 + \pi^2(1 - q\sigma)^2)(1 - q\sigma)^2
\end{gathered}
\tag{C.25}
$$

where the second line follows by multiplication of both sides by σ^4 and the third by dividing both sides by 2 and working out explicitly the square on the LHS. Note that σ and q always appear together in the last line of (C.25). As a consequence, we can redefine $\sigma q := x$ and check whether the condition holds for $x \in [0, 1]$ and $\pi \in [0.5, 1]$. We prove this graphically using figure C8. It plots the difference between LHS and RHS of (C.25) for the whole range of possible values of x and π, showing that this difference is always positive. This completes the proof. ■

Monopoly-Duopoly comparison

Finally, we show that sufficient conditions for competition leading to more research than monopoly can be found in this set up as well.

Proposition 13 *There exists a nonempty interval of v values where $\sigma_D^*(q) > \sigma_M^*(q)$.*

Proof.

A sufficient condition for the proposition to hold is that, for some values of v, $c_D(q) > c_M(q)$. Setting $v = 0$, and defining $B = \frac{1-q\sigma}{\sigma}$ note that:

$$\begin{aligned} c_D(q) &= (\gamma(\emptyset) - \gamma(1))(q\sigma - (1-q\sigma)\pi^2) + 1 - q \\ &= q\sigma \frac{q^2(1-q)}{(1-q\sigma)(q^2+\pi^2B^2)} - \pi^2(1-q\sigma)\frac{q^2(1-q)}{(1-q\sigma)(q^2+\pi^2B^2)} + 1 - q \\ &= (1-q)\left(\frac{q^3\sigma}{(1-q\sigma)(q^2+\pi^2B^2)} - \frac{\pi^2q^2}{q^2+\pi^2B^2} + 1\right) \\ &= (1-q)\left(\frac{q^2+(1-q\sigma)\pi^2B^2}{(1-q\sigma)(q^2+\pi^2B^2)} - \frac{\pi^2q^2}{q^2+\pi^2B^2}\right) \\ &= \frac{1-q}{1-q\sigma}\left(\frac{q^2+(1-q\sigma)\pi^2B^2}{(q^2+\pi^2B^2)} - \frac{\pi^2q^2(1-q\sigma)}{q^2+\pi^2B^2}\right) \end{aligned} \tag{C.26}$$

where the first equality follows by substitution and the rest is a series of rearrangements. Note that, as $q \in (0,1)$, neither $1-q$ nor $1-q\sigma$ are ever 0. Similarly, by substitution,

$$\begin{aligned} c_M(q) &= (1-\pi)\left(\frac{q(\sigma+(1-\sigma)\pi}{q\sigma+q(1-\sigma)\pi+(1-q)\pi)} - \frac{q(1-\sigma)}{1-q\sigma}\right) \\ &= (1-\pi)q\left(\frac{\sigma+(1-\sigma)\pi}{q\sigma(1-\pi)+\pi} - \frac{1-\sigma}{1-q\sigma}\right) \\ &= \frac{(1-\pi)q\sigma(1-q)}{(1-q\sigma)(q\sigma(1-\pi)+\pi)} \end{aligned} \tag{C.27}$$

As a consequence, by comparison of (C.26) and (C.27), $c_D(q) > c_M(q)$ implies

$$\frac{q^2+(1-q\sigma)\pi^2(B^2-q^2)}{(q^2+\pi^2B^2)} > \frac{(1-\pi)q\sigma}{(q\sigma(1-\pi)+\pi)} \tag{C.28}$$

Note that both LHS and RHS of (C.28) are decreasing in π. The case of RHS is straightforward. For the LHS, a sufficient condition is

$$(1-\sigma q)2\pi(B^2-q^2)(q^2+\pi^2B^2-2\pi B^2(q^2+(1-q\sigma)\pi^2(B^2-q^2))<0$$

This simplifies to $-\sigma q 2\pi q^2 B^2-(1-\sigma q)2\pi q^4$ that is always negative.

As a consequence, a sufficient condition for $c_D(q)>c_M(q)$ is LHS($\pi=1$) >RHS($\pi=0.5$). By substitution, this implies

$$\frac{q^2+(1-q\sigma)(B^2-q^2)}{(q^2+B^2)}>\frac{q\sigma}{1+q\sigma}$$

After few simplifications and substituting back the value of B, we obtain

$$\sigma^2q^2\frac{2q\sigma-1}{\sigma^2}+\frac{(1-q\sigma)^3}{\sigma^2}>0$$

A sufficient condition for this to hold is

$$1-3q\sigma+2q^2\sigma^2+q^3\sigma^3>0$$

Noticing that $q\sigma$ is bounded between 0 and 1, the condition is always satisfied and this completes the proof. ■

D Monopoly with public signal

In this appendix we assume that the audience learns the actual timing with positive probability z in monopoly. This helps us establish that additional learning in our benchmark duopoly model happens not only because the timing is revealed with some probability but also because the audience uses additional information from outlets matching the state. In this set up, the outlet does not know whether the audience has learned the timing or not when taking its decision. Then, the condition for doing research is

$$z\gamma_M(2) + (1-z)\gamma_M(\varnothing) - c \geq z\gamma_M(1) + (1-z)(\pi\gamma_M(\varnothing) + (1-\pi)\gamma_M(1)) \tag{D.29}$$

Note that $\gamma_M(2) = \gamma(2) = 1$ and $\gamma_M(1) = \gamma(1) = \frac{1-\sigma}{2-\sigma}$. However,

$$\gamma_M(\varnothing) = \frac{\sigma + (1-\sigma)\pi}{\sigma + (1-\sigma)\pi + \pi} \neq \gamma(\varnothing) = \frac{\sigma^2 + (1-\sigma)(2-\sigma)\pi^2}{\sigma^2 + (2-\sigma)^2\pi^2}$$

because in duopoly the audience can learn also from the other player getting the state wrong. Hence, it is confused only if both outlets publish simultaneously and they both get the state right.

For comparison, we can write the duopoly condition for $v = 0$ a bit differently. Define χ the probability that the opponent behaves in a way that reveals the timing to the reader. Note that χ is "artificial" because it is the probability that j does not research when player i does (i.e. $\frac{1}{2}(1-\sigma^j) + \frac{1}{2}$ on the LHS) and vice-versa (i.e. $\frac{1}{2}\sigma$ on the RHS). In such cases, the action of player j is fully revealing of the timing, irrespective of the endorsement. The duopoly condition for research is then

$$\chi\gamma(2) + (1-\chi)\gamma(\varnothing) - c \geq \chi\gamma(1) + (1-\chi)(\pi^2\gamma(\varnothing) + (1-\pi^2)\gamma(1)) \tag{D.30}$$

Comparing (D.29) and (D.30) reveals that they are similar, but not identical. Even if we set $z = \chi$, the difference in $\gamma(\varnothing)$ and in the π^2 term of the RHS is still there. Hence, our result is not just due to the fact that the publication timing of the opponent reveals information about the timing of the other player. The content of the endorsements plays a role as well.

E Knobel (2018) results on watchdog reporting

Table E1: Deep (first row) and simple (second row) accountability reporting (as a % of total front-page stories in April) in a sample of 9 newspapers in the US for 1991-2011 in five-year gaps

Newspaper group	Newspaper	1991	1996	2001	2006	2011	Average
Large	*Wall Street Journal*	1.28	2.33	5.88	5.26	4.85	4.03
		30.77	22.09	23.53	22.11	27.18	25.06
	Washington Post	1.51	3.55	4.23	2.72	7.74	3.80
		25.63	27.41	31.92	37.50	36.13	31.43
	New York Times	0.34	0.93	4.35	5.43	3.19	2.46
		10.51	9.29	18.26	19.57	28.72	15.82
Metropolitan dailies	*Albany Times Union* (NY)	6.35	1.22	3.45	4.12	3.61	3.64
		47.62	23.17	28.74	17.53	36.14	26.37
	Denver Post	0.00	4.85	1.80	3.06	5.13	2.92
		23.33	22.33	28.83	29.59	43.59	28.96
	Minneapolis Star Tribune	2.46	1.15	1.83	2.86	5.00	2.68
		31.97	36.78	22.02	34.29	41.00	32.89
	Atlanta Journal-Constitution	1.20	0.00	1.06	1.75	11.84	2.30
		14.97	11.11	13.30	30.70	48.68	20.52
Small	*Bradenton Herald* (FL)	0.93	1.61	1.14	1.27	1.44	1.26
		19.44	33.87	32.95	21.52	19.42	24.16
	Lewiston Tribune (ID)	0.00	0.00	0.00	0.00	1.45	0.32
		22.22	15.25	40.74	28.33	23.19	25.80
Average		1.26	1.81	2.92	3.25	4.46	2.69
		21.52	19.78	24.46	27.26	32.59	24.94

Source: *The Watchdog Still Barks: How Accountability Reporting Evolved for the Digital Age*. Knobel (2018). The author analyzed the content of every front-page story that was published in the month of April (randomly selected) in five-year gaps starting 1991 in a select sample of 9 newspapers. The stories chosen for deep and simple categories involved the following procedure. First, the author eliminated stories that were breaking news. Second, she eliminated stories that had no relation to public policy or politics. In all, she analyzed 1,491 stories in depth using content analysis. Simple accountability reports/stories are those that took a few hours or days to complete, relying on straightforward reporting such as interviews or reviewing published documents. Deep accountability reports/stories are those that took weeks or months to develop and would have remained secret without the journalists' work.

We show in Table E1 the data from Knobel's study in support of our theoretical results. Her study paints a more positive image of the future of watchdog reporting. While not exactly the same as reporting accurate stories, watchdog reporting, which includes investigative journalism and fact-checking, takes time. The table shows an increasing share of accountability reporting among a sample of 9 US newspapers for 1991-2011. In particular, note how there is an increase in accountability reporting across categories since 2006. Note that by 2006 the broadband penetration rate in the USA was already 20.23 broadband subscriptions per 100 people (See this link). The increase is visible for both deep and simple accountability reporting, and across newspaper groups. While the increase may be due to several reasons, her data together with the interviews hint at similar path to that which we outline in this paper.