Competition for Attention and News Quality*

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Abstract. Over the past decades, the number of news outlets has increased dramatically but the quality of news products has declined. We propose a model to reconcile these facts, where consumers' attention allocation decisions not only depend on but also affect news outlets' quality choices. When competition is intensified by new entries, the informativeness of the news industry rises. Thus, attention is diverted from existing outlets, reducing their incentives to improve news quality, which begets a downward spiral. Furthermore, when attention becomes cheaper, a larger number of news outlets can be accommodated in equilibrium, but news quality still falls.

Keywords. sender-receiver game, information acquisition, attention allocation, news quality

JEL Classification. D83, D84, L15, L82

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1. Introduction

Media proliferation is the most salient feature of news markets in past decades: the number of news providers has unmistakably grown. The modern news consumer faces a menu of options much richer than before: free dailies and online newspapers, news programs on cable television and podcasts, and a large number of information sources on the internet available at no cost. Consumers indeed spend more time consuming news and gather information from a larger number of news sources. However, in such an enriched news environment, the quality of news reports has declined steadily over time, according to news consumption survey data. The combination of these two trends contradicts a long-held belief that greater media competition leads to higher quality news outlets.[1] The goal of this paper is to reconcile these seemingly puzzling trends and provide a model that is consistent with a number of stylized facts in the news market.

The key idea is built upon the information acquisition literature, which studies how consumers allocate their attention among information sources with fixed information structures (e.g., Sims 2003, Hellwig and Veldkamp 2009, Myatt and Wallace 2012, and Chen et al. 2015). Our contribution is to characterize a feedback mechanism in which consumers' attention may in turn have an impact on the underlying information structure.

Failure to attract attention from news consumers may discourage news outlets from improving news quality. The deterioration in the quality of news content in turn attracts even less attention, which induces a downward spiral. The extreme manifestation of this mechanism is that a news outlet that cannot grab enough attention from consumers ceases to be informative and drops out of the market. This mechanism can be more prominent when competition intensifies and new entries take away the attention of news consumers.[2] In this paper, we build a model to capture this salient aspect of the news media market, emphasizing that consumers' attention allocation and the competition environment affect how news providers choose their news quality.

In our model, news consumers take an action about an uncertain state and may receive news about the state from multiple news outlets. They decide how much attention to give to each outlet and how much weight they attach to its news story. Each outlet is endowed with some evidence about the state. Based on the evidence, each

[1] Economic models of the media industry often emphasize the "cross-checking" effect: a strategic sender is less likely to hide or distort facts if receivers can obtain similar facts from other sources (Gentzkow and Shapiro 2006).

[2] Commentators often worry about a vicious cycle of intense media competition: new entrants compress consumer demand and therefore the production budget for each news producer, "which compromises the quality . . . , further reducing the audience and alienat[ing] the advertisers" (Keen 2007, p. 33).

outlet crafts a news story to balance the desire to inform the public (i.e., align the aggregate action with the uncertain state) and the desire to align the news story with its own ideal position on this issue. The quality of news is high if the outlet chooses to provide news reports that closely reflect the facts; and the quality of news is low if the outlet produces standardized stories that fail to reflect all the nuances of the evidence but instead spend much of the space presenting its own stance on this issue.

The interaction between news readers and news providers is modeled as a sender-receiver game with multiple senders with diverse information. This model exhibits strategic complementarity between news consumers (receivers) and news outlets (senders) and strategic substitution among outlets. Strategic complementarity arises because the more attention news consumers give to a news outlet, the more incentive this outlet has to improve its quality; and the higher the quality of news reports is, the more willing are consumers to pay attention to them. This feature of strategic complementarity is consistent with empirical evidence from online media outlets (Sun and Zhu 2013). Strategic substitution among firms arises because an improvement in the news quality of other outlets shifts attention away from an individual outlet, which reduces the incentive for the outlet to improve its quality. This feature of strategic substitution is broadly consistent with the evidence provided by Gentzkow (2007).

We use this model to study the effects of new entry and media competition on news quality. We show that there is a quantity-quality trade-off. With more news outlets in the market, consumers can read more stories on the same topic, and the overall informativeness of the media industry increases. However, the quality of existing news deteriorates for two reasons. First, as the informativeness of the whole industry improves, the incentive of each individual news outlet to inform the public by improving its news quality is undermined (strategic substitution). Second, better substitutes divert attention away from existing outlets, which further represses their incentives to improve news quality (strategic complementarity).

A byproduct of our analysis shows that there can be a saturation point in the news market. That is, it is not the case that an arbitrary set of outlets can attract a strictly positive amount of attention simultaneously. Underlying this result is the endogeneity of news quality. If news quality is assumed to be fixed, it is indeed optimal for consumers to spread their attention thinly among all firms as the number of news firms grows. However, an outlet that receives only a tiny fraction of consumers' attention does not have the incentive to provide quality news. The strategic complementarity between attention allocation decisions by consumers and news quality choices by outlets produces a downward spiral. The outlet then ceases to be informative, and consumers ignore it. This mechanism puts an upper bound on the number of firms that can be supported in equilibrium.

When the price of attention to news becomes cheaper, consumers spend more time consuming news. Does the quality of news decrease in response? We first show that the total number of news outlets that can be accommodated in the market equilibrium rises and that the aggregate informativeness of the news industry improves in response to a lower attention price. This result is consistent with the observation that the number of media outlets grows when the cost of attention to news is cheaper. We then show that strategic substitution among outlets dominates: competition decreases news quality in equilibrium even though consumers tend to spend more time consuming news. In addition, if we allow the sources of news inputs to be correlated across outlets, news quality also falls when such correlation is high. Since an increase in the number of outlets is likely to be accompanied by a greater correlation in their news sources, this factor can be an additional force that drives down news quality when media proliferate.

In this paper, we examine a combination of understudied features of the news market, namely, that information prevision by news media and information acquisition by news consumers are complementary and that news producers are substitutable. We show that this mechanism is robust in extended and generalized versions of the model. In section 5.1, we study a variant of the model in which consumers' partisan preferences matter for news consumption—they enjoy hearing news from like-minded news sources. We show that our mechanism is still at work even in the presence of such a behavior bias. Section 5.2 further illustrates that we can accommodate a more generalized objective function for news outlets, and our key qualitative results remain unchanged. Furthermore, in our benchmark analysis, the active group of outlets is given and exogenously varied. In section 5.3, we extend the model by adding one more stage where we allow firms to choose to enter the market or not. We derive additional predictions on media proliferation when the entry cost declines.

Literature Review. A recent strand of the media economics literature focuses on the news provision of media outlets and media competition. Perego and Yuksel (2022) show that greater media competition leads to a smaller but more homogenous reader group for each newspaper; consequently, media outlets tilt their resources toward topics closer to the preferences of readers of their own segment and away from topics of general interest. Nimark and Pitschner (2019) study news selection in a setting where readers extract information from both the content of the news and the topic choice made by editors. In our paper, because news consumers spread their attention across multiple firms, competition occurs on the intensive margin. Outlets have only one issue to cover but choose the quality of news reporting. Galperti and Trevino (2020) study endogenous information supply in an environment where an arbitrarily large number of firms engage in perfect competition and emphasize the role of coordination motive among news consumers. By contrast, in our model, consumers consume news only to take informed action, and outlets are strategically substitutable. Sobbrio (2014) studies endogenous news accuracy in a model with partisan bias: news firms can choose editors based on their ideological preferences, who in turn choose the news supply, and consumers turn to like-minded editors for news. Our results are obtained without relying on partisan bias. Furthermore, in an extension of our model, we allow partisan preferences to distort consumers' attention allocation decisions and show that our model mechanisms still hold.

In general, our work is related to the attention allocation literature, in which information acquisition by receivers is plagued by receiver noise; see Hellwig et al. (2012) for a review of the research modeling inattention with alternative approaches. In particular, our model building blocks are based on the Dewan-Mayatt-Wallace framework developed by Dewan and Myatt (2008) and Myatt and Wallace (2012): multiple information sources offer signals with different degrees of accuracy and clarity about an uncertain state, and consumers allocate their attention among those sources and then take an action. Our work differs in three main respects: consumers do not have coordination concerns; the news quality of each information source is endogenously determined; and the number of active information sources is endogenous in equilibrium.

2. Stylized Facts About News Markets

One salient development in the news market in the last few decades is the proliferation of media outlets. Take online news sites as an example. *Columbia Journalism Review* kept track of online news sites from 1999 to 2013 that satisfy the following four criteria: the outlet is primarily devoted to original reporting and content production; it has full-time employees; it is independent and not the web arm of a legacy media entity; and it attracts financial support through advertising, grants, or other revenue sources to sustain its operation. Using data from its publication, *The Guide to Online News Startups*, we show the number of online news sites in Figure 1.

The increase in the number of news outlets in recent decades has intensified competition among news media. New media sources have taken away market shares from existing and established organizations and left many of them struggling. For example, the traditional newspaper industry in the United States has lost 70 percent of advertising revenues since 2000 (Chandra and Kaiser 2015). Concurrently, the total number of reporters, editors and other journalists fell from a peak of 56,400 in 2000 to 32,900 in 2014, a decline of more than 40 percent.[3]

[3]Data obtained from the American Society of News Editors, Newsroom Employment Census 2015. Moreover, it is likely that the decline in advertising revenues leaded to a decrease in the number of

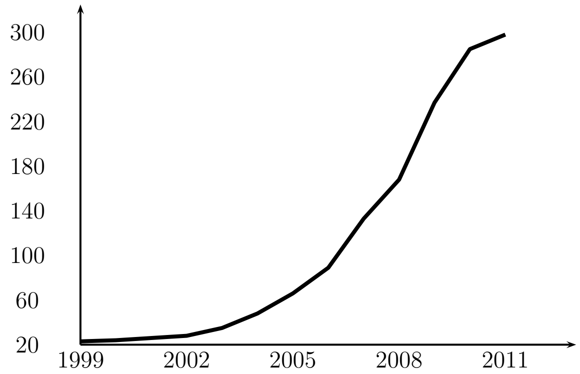

Figure 1. *Number of online news sites. Source: Compiled from the Guide to Online News Startups.*

In this more competitive environment, people spend more time consuming news and are more informed (Kohut et al. 2010). The 2010 wave of the Pew Media Consumption Survey shows that, for an average American, the total time consuming news in a given day rose from 57 minutes in 2000 to 67 minutes in 2006 and to 70 minutes in 2010. This upward trend is driven largely by news consumption online, which offsets the mild decline in time spent consuming news offline. This measure does not take into account the time spent consuming news on cell phones or other digital devices; otherwise, the increase may be even sharper. The longer time spent consuming news is also consistent with the fact that Americans claim that they are better informed, as revealed in the 2014 wave of the Pew Media Survey. The survey shows that 62 percent of respondents claim that they are better informed about local news compared with five years ago, and 75 percent claim to be better informed about national news.

When people spend more time consuming news, they spread their attention among a higher number of media outlets. According to the Pew Media Survey, in 2020, the average minutes per website visit for the top 50 U.S. daily newspapers, based on circulation, was a little less than two minutes. This figure is down approximately 45 seconds from when Pew first began tracking it in 2014.

In such a seemingly enriched media environment, does news quality improve? The general trend in the public's perception about the quality of individual news outlets suggests a steady decline in news quality. In the annual Media Consumption Survey conducted by Pew Research Center, respondents are asked whether they believe that news organizations "get the facts straight" and are "willing to admit their mistakes."[4] The fraction of respondents who offer a positive answer has clearly been

journalists employed by newspapers. Using data on the French daily newspaper industry, Angelucci and Cagé (2019) showed that this causal relationship existed.

[4]The same Pew survey shows that most respondents name a cable news outlet or an established newspaper when they are asked what first comes to mind when they think of "news organizations." Although internet news started becoming prominent in early 2010, cable news outlets and established newspapers (e.g., CNN, FOX, NBC, NYT, WSJ, and USA Today) are still important to people's percep-

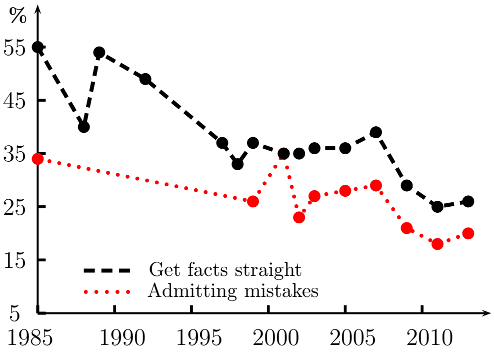

Figure 2. *The fraction of respondents who believe that news organizations are providing accurate news reports in general is steadily declining. Source: Media Consumption Survey, 2013.*

dwindling in the last three decades; see Figure 2. Similar questions regarding other dimensions of news quality have also been asked, for example, "Do you think that their stories and reports are often inaccurate?" and "Would you say news organizations are highly professional?" The trend of decreasing accuracy is consistently confirmed by responses to such related questions. For example, in 1985, only 34 percent of respondents claimed that news organizations often provide inaccurate stories, but 67 percent did so in 2013.[5]

The facts outlined above depict interesting patterns of news consumption in the past decades: an increasing number of news media have emerged and are accommodated in the news market, intensifying competition in the industry; readers spend more time reading news, spread their attention across a larger number of news outlets and are better informed; however, the quality of news products has been decreasing, instead of increasing.

Importantly, the increased number of news media outlets and the intensified competition may not necessarily be responsible for any of these changes. Furthermore, the number of news outlets that can survive in the market may not be exogenous either. In the next section, we provide a model of media competition to reconcile the facts and trends that we describe in this section.

3. Media Quality and Attention Allocation

3.1. News Outlets

There is a continuum of ex ante homogenous news consumers indexed by $i \in [0, 1]$, who acquire information from the media about an uncertain state θ and take an ac-

tion of the news media.

[5]Pew Research Center Media Consumption Survey, "The People and the Press," 2013.

tion q_i. In the news market, there is a large number of news outlets indexed by $j \in \{1, \ldots, J\}$ that are heterogeneous. News outlets and consumers share a common prior belief that θ is normally distributed, with mean μ and variance v_θ. Each outlet is endowed with some evidence about the issue, i.e., a noisy signal about the true state. Let $x_j = \theta + \epsilon_j$ represent such a signal, where ϵ_j is normally distributed with mean 0 and variance $v_{\epsilon j}$ (and is independent of the state and across news outlets).[6] Let $\gamma_j := v_\theta / (v_\theta + v_{\epsilon j})$ represent a measure of the signal-to-noise ratio of the evidence possessed by news outlet j.

Outlet j publishes a news story y_j about θ with two objectives in mind. First, it prefers that the aggregate action taken by news consumers, $Q = \int_0^1 q_i \, \mathrm{d}i$, is close to the true θ. This aspect represents the incentive to inform the public about the correct action to be taken. The motive of informing the public is common and realistic, given "the central purpose of journalism is to provide citizens with accurate and reliable information they need to function in a free society," as stated by American Press Association.[7] Second, each outlet j also prefers that the message delivered from the news story is close to the outlet's ideal position ξ_j, which can be interpreted as the established editorial stance of this news outlet. This aspect represents the incentive to disseminate messages that the outlet prefers, or the expressive value from slanting the news.[8] In summary, outlet j chooses y_j to maximize the expected payoff,

$$U_j = -\mathrm{E}\left[(Q - \theta)^2 + \phi_j (y_j - \xi_j)^2 \,\middle|\, x_j \right], \tag{1}$$

where ϕ_j is the weight assigned to the expressive motive. A higher ϕ_j means that the outlet cares more about its own editorial stance and less about informing the public.[9]

In this model, news outlets do not directly maximize attention from news consumers, but they choose reporting strategies to induce consumers' action to rely on their news products. We will show in section 3.4 that such reliance by consumers is in proportion to the attention paid to each outlet.[10] This objective captures the standard reputation mechanism: the outlet informs the public of quality news, the public trusts and pays attention to it, and the outlet monetizes the attention received.[11]

[6] It is realistic to expect that the noise term may be correlated across news outlets conditional on the state. We consider such a scenario in section 4.4.

[7] See `https://americanpressassociation.com/principles-of-journalism/`.

[8] Our assumption regarding the expressive motive resembles Brennan and Buchanan (1984) and Brennan and Lomasky (1997), in which market and ballot choices of individuals consist of both instrumental and expressive elements.

[9] Note that news outlets are heterogeneous in three dimensions: the evidence each outlet gathers, its own editorial stance, and the weight each outlet assigns to it.

[10] News outlets often adopt attention-grabbing techniques to increase the attention they receive from news consumers, such as designing eye-catching headlines or providing materials that inspire outrage, anger or fear, which are beyond the scope of this paper.

[11] In our model, inducing reliance and attracting attention are two sides of one coin. This setup allows

This objective function deserves further discussion. First, the ideal position ξ_j of each outlet can be interpreted as an ideological stance, e.g., liberal or conservative. Section 5.1 provides a variant of this model, which allows consumers' attention decisions to be influenced by such ideological stances. Second, we assume that outlets dislike deviating from their own editorial stance ξ_j in the benchmark model, where we obtain close form solutions. In section 5.2, we generalize the objective function and show that the qualitative properties of this model would not change when we incorporate other possible motives for the news outlets (such as allowing the editorial stance to be state dependent). Third, in this benchmark case, we focus only on the reporting strategy of *active* outlets that exist in the market. In section 5.3, we explicitly incorporate an analysis of how news outlets weigh the (advertising) revenue from attention and entry cost and make entry decisions.

The reporting strategy of outlet j is represented by $\sigma_j : \mathcal{R} \to \mathcal{R}$, which maps the news source x_j to a news story y_j. We focus on equilibria in which the reporting strategy takes a linear form:

$$\sigma_j(x_j) = \alpha_j x_j + \alpha_{j0}. \tag{2}$$

We stress that the outlet chooses a story y_j to report; the pair of (α_j, α_{j0}) is just a compact way of representing its reporting strategy in a linear equilibrium. The constant term α_{j0} is shifted by ξ_j, representing a fixed or expected position of the outlet j on this issue. The "strategy" of news outlets is summarized by the vector $\boldsymbol{\alpha} := (\alpha_1, \ldots, \alpha_J)$.

For a news article, α_j corresponds to the notion of quality, which refers to how facts (and information) are presented. A high α_j means that the story closely reflects the evidence (or the underlying signal), while a low α_j represents a "cookie-cutter" style of reporting that produces standardized stories that fail to reflect all the nuances of the evidence. In other words, the outlet is considered to be high quality if its news story is fact-intensive with high α_j (e.g., spending generous space describing facts and enriching the story). The other side of the same coin is that how the news content is presented also matters in determining to what extent readers can understand the news content with ease. This interpretation will become clearer once the information extracted from outlet j by news consumers is fully described in equation (4) below.

3.2. News Consumers

News consumers acquire information about θ from the media. They choose not only which news reports to pay attention to but also how much attention they pay to each

the news article provided by each outlet to be fully endogenous. However, fake news outlets may use an alternative strategy to attract attention instead of providing quality news. The rise of fake news agencies was a recent phenomenon and started much later than the emergence of the trends we described in section 2. We leave those aspects of the news market, such as the interaction of mainstream media and fake news outlets, for future research.

report. If consumer i picks up the news report y_j, she reads the news content with reader noise η_{ji} attached to the actual report. That is, she observes

$$\hat{y}_{ji} = y_j + \eta_{ji}, \tag{3}$$

where η_{ji} is normally distributed with mean 0 and variance $v_{\eta ji}$, and is independent of y_j and independent across news consumers. This specification captures the idea that an individual has limited capacity to process all the information contained in a story; she reads the content of a news story with actual or interpretive errors. The variance of interpretive errors or reader noise is not exogenous. It depends on the attention or capacity spent on the news story. News consumer i can read a news story with greater precision by paying more attention to it. Let z_{ji} represent the amount of attention devoted to news outlet j. The noise reduction technology is specified as:

$$v_{\eta ji} = \frac{\chi}{z_{ji}},$$

where χ is a constant that captures the technological aspect of the information assimilation process. If consumer i pays no attention to the news story j, i.e., $z_{ji} = 0$, the variance of the reader noise is infinite and the news content is totally uninformative. If consumer i pays an infinite amount of attention to news story j, the variance of the reader noise is zero, and consumer i obtains story y_j precisely. This noise reduction technology is commonly adopted in the attention allocation literature: the precision of the noise is linearly related to the attention devoted to the information source (Myatt and Wallace 2012; Mondria and Quintana-Domeque 2013).

Implicitly, news quality plays a role in the information transmission process. Given a linear reporting strategy, the information content in $\hat{y}_{ji}$ can be written as:

$$\frac{\hat{y}_{ji} - \alpha_{j0}}{\alpha_j} = \theta + \left(\epsilon_j + \frac{1}{\alpha_j}\eta_{ji}\right). \tag{4}$$

For a fixed amount of attention z_{ji}, the effective reader's noise, $\epsilon_j + \eta_{ji}/\alpha_j$, is smaller when α_j is higher. That is, for the same amount of attention paid, higher-quality news reports give rise to less reader noise and are easier to understand.

The information set available to consumer i is an array of perceived reports, $(\hat{y}_{1i}, \ldots, \hat{y}_{Ji})$. Given this information set, consumer i chooses action q_i to maximize $-\mathrm{E}[(q_i - \theta)^2]$. The optimal action rule, $\tilde{q}_i : \mathcal{R}^J \to \mathcal{R}$, maps the J perceived news reports to an action taken by consumer i. In a linear equilibrium with Gaussian signals, the optimal action rule is also linear:

$$\tilde{q}_i\left(\hat{y}_{1i},\ldots,\hat{y}_{Ji}\right)=\beta_{0i}+\sum_{j=1}^{J}\beta_{ji}\hat{y}_{ji}. \tag{5}$$

Because news consumers are ex ante identical, they make the same information choices in a symmetric equilibrium. We focus on equilibria in which their attention and action rules are identical (but their actions taken may be different since each consumer perceives a different report $\hat{y}_{ji}$ based on the same story y_j). From here on, we drop the subscript i, which refers to consumer i. The attention allocation of news consumers is summarized by the vector $\boldsymbol{z}:=(z_1,\ldots,z_J)\in\mathcal{R}^J$, and the common action rule is $\tilde{q}(\cdot)$. The strategy of news consumers is represented by $\sigma^R:=(\boldsymbol{z},\tilde{q})$. When the action rule $\tilde{q}(\cdot)$ is linear, it can be represented by the constant β_0 and the vector of weights $\boldsymbol{\beta}:=(\beta_1,\ldots,\beta_J)$ that they attach to the perceived stories of the news outlets. The constant does not play a role in our analysis, and we focus on the weights or *reliances* $\boldsymbol{\beta}$.

In summary, the objective of a news consumer is to choose q and $\boldsymbol{z}$ to maximize her net payoff:

$$\max_{\boldsymbol{z}}\left\{\max_{q}\left\{-\mathrm{E}\left[(q-\theta)^2\,\middle|\,\hat{y}_1,\ldots,\hat{y}_J\right]\right\}-\sum_{j=1}^{J}pz_j\right\}, \tag{6}$$

where p is the marginal cost of paying attention to news.

Outlets simultaneously choose a reporting rule σ_j that specifies what story y_j to publish based on the news sources x_j endowed. News consumers choose their attention allocation $\boldsymbol{z}$ and their action rule $\tilde{q}$, which specifies what actions to take based on the perceived stories $\hat{y}_j$ ($j=1,\ldots,J$) they read. The outlets and news consumers play a sender-receiver game with multiple senders and multiple receivers. The strategy profile $(\sigma_1,\ldots,\sigma_J,\sigma^R)$ is an equilibrium if each player's strategy is a best response to others' strategy.

We take two steps to analyze this model. In Section 3.3, we first fix the attention allocation $\boldsymbol{z}$ chosen by readers and study how outlets' reporting "strategies," represented by the quality vector $\boldsymbol{\alpha}$, respond to reliances $\boldsymbol{\beta}$ chosen by readers; and vice versa. The solution to this sender-receiver game allows us to characterize the influence of individual news outlets and to derive an aggregate variable that summarizes the influence of the media industry as a whole. In Section 3.4, we study the attention allocation decision $\boldsymbol{z}$ of news consumers.

3.3. The Sender-Receiver Game

We begin by characterizing news consumers' action rule $\tilde{q}(\cdot)$, represented by the vector of reliances $\boldsymbol{\beta}$. The reader's quadratic loss utility function implies that

$$q = \mathrm{E}[\theta \mid \hat{y}_1, \ldots, \hat{y}_J] = \frac{1}{1 + \sum_k \tau_k}\mu + \sum_j \frac{\tau_j}{1 + \sum_k \tau_k} \frac{\hat{y}_j - \alpha_{j0}}{\alpha_j}. \tag{7}$$

where τ_j represents the precision of the combined noise term (relative to the precision of the prior belief), i.e.,

$$\tau_j = \frac{1}{\frac{1-\gamma_j}{\gamma_j} + \frac{\chi}{z_j \alpha_j^2 v_\theta}}.$$

Note that the action rule (7) is indeed linear in $\hat{y}_j$, with a coefficient given by:

$$\beta_j = \frac{1}{\alpha_j} \frac{\tau_j}{1 + \sum_k \tau_k}. \tag{8}$$

Now we turn to the news outlets' reporting strategies. Each individual outlet j chooses a story y_j to maximize its payoff U_j described in equation (1), given the strategies of news consumers and of other outlets. The solution to the first-order condition leads to:

$$y_j = \frac{\gamma_j \beta_j}{\beta_j^2 + \phi_j} \left(1 - \sum_{k \neq j} \alpha_k \beta_k\right) x_j + \text{constant} \tag{9}$$

Note that the reporting strategy (9) above is indeed linear in x_j, with a coefficient given by:

$$\alpha_j = \frac{\gamma_j \beta_j}{\beta_j^2 + \phi_j} \left(1 - \sum_{k \neq j} \alpha_k \beta_k\right). \tag{10}$$

The constant term in (9) depends on ξ_j but is otherwise unimportant for our analysis.

An important feature of this multisender game is that the reporting strategies of news outlets exhibit strategic substitution: a higher α_k ($k \neq j$) lowers α_j. This feature arises because the objectives of all outlets are partially aligned, that is, they prefer that the public be informed. In other words, the return on improving a news outlet's quality is lower when the quality of the news environment is higher.

The extent to which outlets care about propagating their preferred message also matters. Consider the case that the expressive motive ϕ_j goes to infinity. Then, outlet j does not care about informing the public, and always reports $y_j = \xi_j$ (i.e., $\alpha_j = 0$ and $\alpha_{j0} = \xi_j$), which is its preferred stance about the issue without informative content.

Given a linear reporting strategy and a linear action rule, when the source x_j of outlet j increases by 1, news readers' aggregate action increases on average by $\alpha_j\beta_j$. We call $\alpha_j\beta_j$ the *influence* of outlet j. We further define the *total influence* of news reports to be $H := \sum_k \alpha_k\beta_k$. Using equation (8), we find that

$$H = \frac{\sum_j \tau_j}{1 + \sum_j \tau_j}.$$

Thus, we sometimes also refer to H as *total media informativeness* (relative to the prior). It provides a summary measure of the informativeness of the media as a whole, given by H. This variable is key in our model.

Given any attention allocation $\boldsymbol{z}$, the equilibrium $(\hat{\boldsymbol{\alpha}}, \hat{\boldsymbol{\beta}})$ of the sender-receiver game can be obtained by solving (8) and (10) jointly. We call a set of outlets G an *active media group* if and only if any outlet $j \in G$ receives non-zero attention (i.e., $z_j > 0$) and has positive influence (i.e., $\hat{\alpha}_j\hat{\beta}_j > 0$). For given $\boldsymbol{z}$, there can be multiple equilibria in this sender-receiver game with different active media groups.

Proposition 1. *Given attention allocation $\boldsymbol{z}$, an equilibrium $(\hat{\boldsymbol{\alpha}}, \hat{\boldsymbol{\beta}})$ of the sender-receiver game exists. In such equilibrium, there is an active media group G such that (a) if $j \notin G$, then $\hat{\alpha}_j = \hat{\beta}_j = 0$; and (b) if $j \in G$, then*

$$\hat{\beta}_j^2 = \frac{(h_j - H_G)\phi_j}{(1-\gamma_j)(1-h_j)}, \qquad \hat{\alpha}_j^2 = \frac{\gamma_j^2(h_j - H_G)(1-h_j)}{(1-\gamma_j)\phi_j};$$

where

$$h_j(z_j) := 1 - \sqrt{\frac{\phi_j \chi}{z_j \gamma_j v_\theta}}, \tag{11}$$

$$H_G := \frac{\sum_{k\in G} \frac{\gamma_k}{1-\gamma_k} h_k(z_k)}{1 + \sum_{k\in G} \frac{\gamma_k}{1-\gamma_k}}. \tag{12}$$

Moreover, an equilibrium with nonempty G exists whenever there exists an outlet j such that $h_j(z_j) > 0$.

For any given $\boldsymbol{z}$, $G = \emptyset$ is always an equilibrium (babbling equilibrium). Proposition 1 provides a condition to ensure that at least one equilibrium is non-babbling. For given $\boldsymbol{z}$ and a particular nonempty active media group G, the corresponding value of the equilibrium $(\hat{\boldsymbol{\alpha}}, \hat{\boldsymbol{\beta}})$ is unique. Proposition 1 implies that, for an outlet j in the active media group, its influences is given by:

$$\hat{\alpha}_j\hat{\beta}_j = \frac{\gamma_j}{1-\gamma_j}(h_j - H_G) > 0. \tag{13}$$

Thus, the influence $\hat{\alpha}_j\hat{\beta}_j$ increases in attention z_j but decreases in ϕ_j. Importantly, when the aggregate influence H_G rises, the influence of individual outlet j falls. This outcome occurs because both the news quality $\hat{\alpha}_j$ and reliance $\hat{\beta}_j$ fall when the aggregate influence is larger. Additionally, other news outlets affect the influence of outlet j only through the aggregative variable H_G.[12]

3.4. Attention Allocation Decision

Because a news consumer's action q is chosen to be equal to the posterior mean of θ, the expected value of the quadratic loss function $(q-\theta)^2$ is simply the posterior variance of θ, which is equal to the inverse of the sum of the prior precision and the precisions from all the signals about θ. At the attention allocation stage, a news consumer's objective (6) can be written as

$$V = -\frac{v_\theta}{1+\sum_j \tau_j} - \sum_j p z_j,$$

where τ_j is given by equation (3.3) and increases in z_j. The first-order conditions for z_j are:

$$\frac{\tau_j}{1+\sum_k \tau_k}\frac{1}{z_j\alpha_j} - \sqrt{\frac{p}{\chi}} = 0. \tag{14}$$

By equation (8), $\tau_j/(1+\sum_k \tau_k)$ is simply the influence $\hat{\alpha}_j\hat{\beta}_j$ of news outlet j. Therefore, equation (14) shows that the attention allocated to each news outlet is proportional to its reliance on news outlet j, i.e., $z_j = \hat{\beta}_j\sqrt{\chi/p}$. Note that we do not ascribe a causal interpretation to this relationship because attention and reliance are jointly determined.

Using Proposition 1, we can express the first-order conditions (14) solely in terms of z_j and H, as in the following lemma.

Lemma 1. *Considering that $\hat{\boldsymbol{\alpha}}$ and $\hat{\boldsymbol{\beta}}$ are endogenously determined in the sender-receiver game, a reduced-form first-order condition for z_j is given by:*

$$\frac{\gamma_j^2 v_\theta^2}{(1-\gamma_j)\phi_j\chi}(h_j - H_G)(1-h_j)^3 = p. \tag{15}$$

The left-hand side of this equation increases and then decreases in h_j, reaching a maximum at $h_j = (1+3H_G)/4$, and h_j always increases in z_j.

We depict both sides of the key equation in Figure 3. Holding H_G fixed, the left-hand side of (15) is hump-shaped in z_j. There are two opposing effects. First, there

[12] If we sum equation (13) over j, we observe that $H_G = \sum_j \hat{\alpha}_j\hat{\beta}_j = \mathrm{Cov}[Q,\theta]/v_\theta$. The higher H_G is, the more effective the industry is in informing the public to choose an aggregate action Q that closely matches the true state θ.

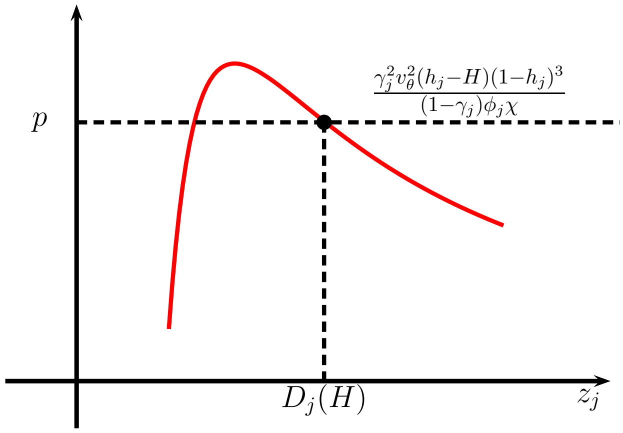

Figure 3. *The reduced-form marginal benefit of attention increases and then decreases in z_j. The key equation (15) has either two solutions or no solution. When there are two solutions, the demand function $z_j = D_j(H)$ is defined to be the larger root.*

are diminishing returns to attention devoted to each news source: for fixed $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, $\partial^2 V / \partial z_j^2$ is negative. This result is reflected in the term $(1 - h_j(z_j))^3$, which accounts for the decreasing part of the graph and is a common mechanism in models with information acquisition choice. The counteracting effect is that as news consumers pay more attention to news outlet j, their reliance on its story and the quality of outlet j will change in equilibrium.

Proposition 2 (Feedback Mechanism)**.** *When news consumers pay a larger amount of attention to outlet j (i.e., z_j increases), outlet j improves its news quality in response (i.e., $\hat{\alpha}_j$ increases), and consumers rely more on news from this outlet (i.e., $\hat{\beta}_j$ increases).*

The first part of this proposition represents the key difference of this model from the existing literature: the attention allocation decision will affect the underlying information structure. Specifically, Bayes' rule requires that consumers rely more on outlet j as reader noise decreases when they pay more attention to this outlet. However, as consumers rely more on its stories, outlet j can better inform the public by raising its news quality $\hat{\alpha}_j$, i.e., devoting more space to a description of facts and reflecting richer details of the evidence. This change in turn induces an even higher reliance $\hat{\beta}_j$ in equilibrium.

A higher $\hat{\alpha}_j$ implies that the marginal benefit for a news consumer from paying attention also increases, because $\partial^2 V / \partial \alpha_j \partial z_j > 0$. This effect is reflected in the term $(h_j(z_j) - H)$ in equation (15), which increases in z_j, and it accounts for the increasing part of the graph in Figure 3. Without the endogenous news quality choice (determined in the sender-receiver game), the marginal benefit of paying attention should be monotonically decreasing, as in the existing literature.

Given the total influence H, the key equation (15) determines the attention z_j given to each news outlet j. Equation (15) admits either two solutions or no solution. When there are two solutions, we focus on the larger solution because it is a locally "stable" root and provides intuitive comparative statics results. We denote this larger root by $z_j = D_j(H)$; see Figure 3.

Lemma 2. *Attention to outlet j is given by:*

$$D_j(H) = \begin{cases} \max\left\{z_j : \frac{\gamma_j^2 v_\theta^2}{(1-\gamma_j)\phi_j \chi}(h_j(z_j) - H)(1-h_j(z_j))^3 = p\right\} & \textit{if } H \leq \overline{H}^j, \\ 0 & \textit{otherwise.} \end{cases} \quad (16)$$

Attention to outlet j decreases when total informativeness H increases (i.e., $D(\cdot)$ is decreasing) and is discontinuous in H. Moreover, $D_j(H)$ decreases when attention cost p increases.

The key result in Lemma 2 is that attention to news outlet j falls when the total influence H of the news industry is higher. This result is intuitive: a more informative news industry means that news outlet j faces competition from better substitutes when news consumers allocate their attention. Furthermore, the feedback mechanism (i.e., Proposition 2) implies that outlet j provides news of lower quality and therefore attracts even less attention. In this model, strategic substitutability among news outlets is endogenous and is broadly consistent with empirical findings about the media market.[13]

Thus far, we characterize the optimal attention allocation among existing media outlets, taking into account the feedback mechanism through which attention allocations also affect news outlets' quality choice. The amount of attention paid to outlet j depends on its own characteristics and on the aggregate informativeness of the news industry. In the next section, we characterize the equilibrium of the news market and analyze the impact of news outlet entry on news outlets' quality choice and news consumers' attention choice.

4. Media Proliferation, News Quality, and Attention Allocation

4.1. Equilibrium

In the previous section, attention z_j to outlet j is specified as a function $D_j(H)$ of total informativeness H through equation (16). Total informativeness, in turn, is determined by the optimal attention allocation vector $\boldsymbol{z}$ through equation (12) of the sender-

[13] For example, Gentzkow (2007) finds that online and print versions of news sources are significant substitutes instead of complements once consumer heterogeneity is properly controlled for. Wallsten (2015) also finds that increased attention spent on the internet, such as obtaining news, is associated with less attention to television.

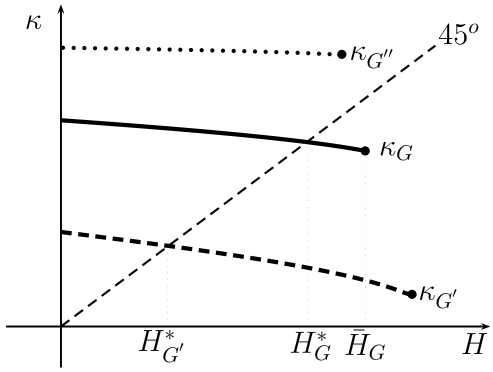

Figure 4. *The function $\kappa_G(H)$ is well-defined on the interval $[0, \overline{H}_G]$ and is downward sloping. The fixed point of $\kappa_G(\cdot)$ is an equilibrium. There is also an equilibrium with active media group G' for any $G' \subset G$, but there may not be an equilibrium with active media group G'' if $G'' \supset G$.*

receiver game. To characterize the equilibrium, we use equations (11), (12) and (16) to define an aggregator function:

$$\kappa_G(H) := \frac{\sum_{j \in G} \frac{\gamma_j}{1-\gamma_j} \left(1 - \sqrt{\frac{\phi_j \chi}{D_j(H)\gamma_j v_\theta}}\right)}{1 + \sum_{j \in G} \frac{\gamma_j}{1-\gamma_j}}.$$

Equilibrium in this model is determined by the condition that

$$H^*_G = \kappa_G(H^*_G).$$

Given H^*_G, the corresponding equilibrium attention allocation is $z^*_j = D_j(H^*_G)$ for $j \in G$. Equilibrium quality α^*_j and reliance β^*_j can be recovered from Proposition 1.

Proposition 3 (Equilibrium Existence)**.** *The aggregator function $\kappa_G(\cdot)$ is decreasing, and for every H, $\kappa_G(H)$ decreases in attention cost p. For any $G \subseteq \{1, \ldots, J\}$, there exists $\overline{p} > 0$ such that an equilibrium with active media group G exists if $p \leq \overline{p}$. Moreover, when such equilibrium exists, the value of H^*_G is unique.*

In Figure 4, the aggregator function $\kappa_G(\cdot)$ is illustrated with the solid curve. It is downward-sloping because an increase in total influence H reduces the influence of each outlet through a chain of responses: consumers pay less attention to each outlet (Lemma 2), and therefore, the news quality of each outlet falls (Proposition 2). Note also that $\kappa_G(H)$ is well defined only when $z_j = D_j(H)$ is positive for $j \in G$, which holds if $H \leq \overline{H}_G := \min_{j \in G} \overline{H}^j$. When attention is cheap and abundant, $\overline{H}_G$ is sufficiently close to 1, and a unique equilibrium must exist.

4.2. Effects of Entry

If an equilibrium exists for active media group G, then an equilibrium also exists for any smaller group $G' \subset G$. News consumers can simply ignore news outlets in the set $G \setminus G'$, and those outlets receive no attention at all. However, for any H, the news quality of outlets in group G' and attention to these outlets remain the same. Thus, $\kappa_{G'}(H)$ shifts below $\kappa_G(H)$, and the equilibrium with the smaller active media group is less informative (i.e., $H^*_{G'} < H^*_G$) than the one with a larger group, as shown by the dashed line in Figure 4.

Lemma 3 (Saturation)**.** *For any $G' \subset G$, an equilibrium with active media group G' also exists, with $H^*_{G'} < H^*_G$. However, for some $G'' \supset G$, there may not exist an equilibrium with the active media group G''.*

To understand the second part of Lemma 3, suppose, for a given H, outlets in the group $G'' \setminus G$ receive positive attention. Then, $\kappa_{G''}(H)$ rises above $\kappa_G(H)$ because the news quality of outlets in group G and the attention to these outlets remains the same (outlets in group G are affected by outlets outside G only through H). A higher $\kappa_{G''}(\cdot)$ implies that the corresponding fixed point must be higher if a fixed point exists. However, recall that attention to each outlet is discontinuous in H. When H is higher than $\overline{H}_{G''}$ (which is less than $\overline{H}_G$), some outlet $j \in G''$ may not receive attention from consumers and may drop out from the active group G''. The dotted line in Figure 4 illustrates such a situation. This result implies that the media market cannot support an arbitrarily large set of news outlets. In other words, the news media market may reach a *saturation point* where any larger set of news outlets cannot be supported in equilibrium.

In the following proposition, we analyze the effect of entry on the existing firms and on market aggregate, when there is still room for new entrants into the market.

Proposition 4 (Competition and News Quality)**.** *Consider an equilibrium in which there are n heterogeneous firms and the industry has not reached the saturation point. When a new firm e is introduced, in the new equilibrium with $n+1$ firms: (a) the total media influence H^* is higher; and (b) the news quality of each incumbent outlet j decreases, and consumers pay less attention to and rely less on each firm in choosing their action, i.e., α^*_j, z^*_j, and β^*_j all fall.*

Part (a) of Proposition 4 follows directly from Lemma 3. As the total influence H^* increases upon entry, the quality of incumbent news outlet j falls for two reasons. First, Proposition 1 implies that the return to improving quality declines (i.e., strategic substitution). Second, a new entrant takes attention from the existing news outlets, and Proposition 2 dictates that news quality shall decrease in response (i.e., strategic complementarity). This result is broadly consistent with the puzzling trend that an increase in the number of news outlets is accompanied by a decline in news quality. Our model is also consistent with the fact that news consumers are more informed when there are more news outlets to pay attention to and they indeed spread their attention over a larger number of media outlets.

4.3. Attention Cost, Market Structure, and News Quality

As discussed in section 2, news consumers have been spending more time consuming news, meaning that they have been reallocating attention from elsewhere to news consumption. This trend occurs partly because the development of news delivery technology makes paying attention to news cheaper, such as referrals by news aggregators and instant notifications from subscribed news sources. Does the lower price of attention to news contribute to media proliferation and a decline in news quality?

We study this issue in a special case of the model, in which news outlets are identical, i.e., the weight ϕ assigned to ideological stance and the precision of evidence γ are the same across firms. This case allows us to capture the size of the news industry simply by using the number of news outlets. Note that if news outlets are heterogeneous, there may or may not exist a "largest equilibrium" in that the active media group G in the largest equilibrium is a superset of the active media group in any equilibrium.[14]

Lemma 4. *For any given attention price p, (i) attention paid to each outlet decreases with the number of outlets; and (ii) there exists an upper bound $\overline{n}$ such that in any equilibrium, the number of active outlets must be lower than $\overline{n}$.*

When there are more active media outlets, Proposition 4 dictates that there is an increase in H_G (induced by a larger number of active firms). The amount of attention to each outlet $D_j(H_G)$ would fall. This result is shown by the decrease from z_1 to z_2 in Figure 5 as the number of active firms increases from n_1 to n_2 and the total influence H_G increases.

Suppose that the number of firms further increases to n_3 and that each of them receives a strictly positive amount of attention; the hump-shaped reduced-form marginal benefit is always below the cost of attention p. Therefore, equilibrium cannot sustain a symmetric outcome in which all n_3 news outlets are active. That is, a fraction of news outlets (e.g., $n_3 - n_2$) must be ignored, and only n_2 outlets can receive a positive amount of attention. Since the number of active firms remains finite, the attention that each active media outlet receives remains bounded away from zero (it cannot fall below z_2 in Figure 5).[15]

[14] It is possible that one equilibrium active media group is neither a subset nor a superset of another

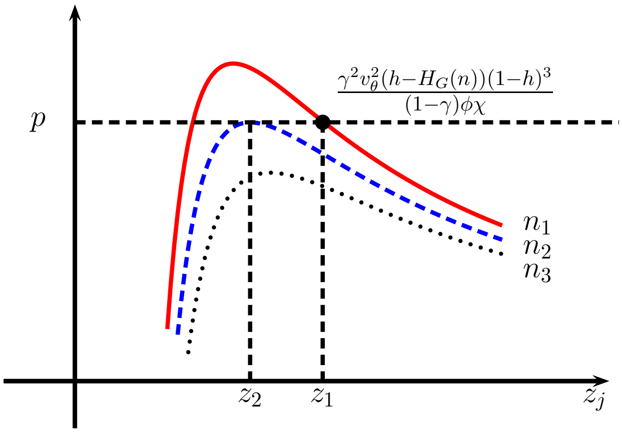

Figure 5. *When the number of firms increases from n_1 to n_2, total media informativeness increases, and the solid curve shifts down accordingly. The equilibrium amount of attention devoted to each outlet drops from z_1 to z_2. In this case, n_2 is the largest number of media outlets that consumers can pay attention to, and z_2 is the smallest possible amount of attention paid to each outlet. Any equilibrium with a larger number of active firms (e.g., n_3) cannot be sustained.*

Remark. If news quality α is exogenous, any number of news outlets can be accommodated in the market, and each of them receives a positive amount of attention, which goes to zero when the total number of outlets approaches infinity.

To see this result, note that in a symmetric model with n news outlets and exogenous α, the first-order condition (14) provides a necessary condition for optimal attention allocation, implying that attention paid to each outlet must be symmetric, with

$$z = \max\left\{\frac{\frac{\sqrt{\chi}}{\alpha\sqrt{p}} - \frac{\chi}{\alpha^2 v_\theta}}{\frac{1-\gamma}{\gamma} + n}, 0\right\}.$$

This remark relates our contributions to the existing literature. Our analysis reveals that models with exogenous and endogenous information quality can deliver qualitatively different predictions about the news market. We show that there is an upper bound for the number of media firms that can receive attention and a lower bound for the amount of attention that has to be paid to each active firm. Both results are

equilibrium active media group.

[15]Our finding that there is an upper limit for the number of firms that can be supported in equilibrium resembles that of Sutton (1991), in which the number of firms reaches a limit even when market size is arbitrarily large. However, the underlying mechanisms are different. In Sutton (1991), such a result arises because the sunk cost prior to entry is endogenous. In contrast, an upper bound for the number of firms exists in our model because of the endogenous quality of news and the complementarity of news production and consumption. Furthermore, Chahrour (2014) shows that when a central bank increases the scope of communication (i.e., sending a larger number of signals), the total informativeness for market participants may decrease (i.e., information overloading). This result is obtained when market participants have incentives to coordinate. Similarly, Dessein, Galeotti, and Santos (2016) study a model with attention allocation where only a subset of tasks should be given attention when tasks complement each other. In our model, consumers do not have a desire to coordinate.

driven by the endogenous choice of news quality. When news quality is exogenous, only the mechanism of diminishing returns to attention matters for attention allocation decisions, and consumers readily spread their attention among as many outlets as possible.

Proposition 5. *Consider the equilibrium where the number of active news outlets is always $\overline{n}$, i.e., the maximum number of outlets that can be accommodated in the market. When the cost of attention to news declines, the upper bound $\overline{n}$ rises, the total amount of attention paid to news increases and the news quality declines.*

When the aggregate informativeness of the industry rises (e.g., caused by a larger number of outlets), the reduced-form marginal benefit of paying attention to an individual news outlet decreases (i.e., strategic substitution). This result implies that the number of new outlets that can be accommodated in equilibrium shall rise when the attention cost of news is lower. In this model, in response to a lower attention cost, the total amount of attention paid to news rises.

However, the attention received by an individual outlet does not rise. On the one hand, because the aggregate informativeness of the news industry is higher, attention to individual news outlets is lower. On the other hand, attention is cheaper, and consumers tend to allocate more attention to each outlet. In the case of homogenous outlets, the two effects cancel out. In other words, the total amount of attention rises only through the extensive margin (i.e., a larger number of outlets in equilibrium). Because attention (and hence $h(z)$) does not change but total informativeness H increases, the news quality of each outlet falls, as predicted by Proposition 1.

Our results in this section reconcile a number of facts documented in section 2. We show that the decline in the price of attention to news induces a larger amount of attention from news consumers and helps accommodate an increasing number of news outlets and that consumers spread their attention among a larger set of news outlets in an enriched news environment, but the quality of news falls.

4.4. Correlated Information Production

In our benchmark model, we assume that the facts obtained by news outlets are conditionally independent. However, journalists from competing news outlets may share common news sources—they may interview similar sets of witnesses or consult overlapping groups of experts. Thus, the news gathering process is likely to produce source materials that are correlated across news outlets , even conditional on the true state. As a byproduct of media proliferation, the input of news production, to which outlets have access, became more correlated with each other. Does this feature also contribute to the decline in news quality? In this section, we embed this concern into our model and examine the impacts of correlation in news production.

Assume that the news source for outlet j is a signal $x_j = \theta + \epsilon_j + \zeta_j$, where $\epsilon_j \sim N(0, v_{\epsilon j})$ is independent across firms as before. The noise $\zeta_j \sim N(0, v_\zeta)$, however, is correlated across firms. Specifically, let $\mathrm{Cov}[\zeta_j, \zeta_k] = \rho v_\zeta$, where $\rho \in [0, 1]$ indicates the degree of correlation and define $R := 1 + \rho v_\zeta / v_\theta$. The accuracy of news source x_j is $\gamma_j = v_\theta / (v_\theta + v_{\epsilon j} + v_\zeta)$.

Proposition 6. *Suppose all firms are identical. In a symmetric equilibrium, a higher correlation in news production reduces the total informativeness (or influence) of the industry. Both the attention paid to each outlet and the news quality of each outlet fall.*

From the perspective of news outlets, when the degree of correlation is high (i.e., when R is large), outlet j expects other outlets to publish stories that are similar to its own news source x_j. Its incentive to publish a story that closely reflects x_j to inform the public is diminished. Therefore, the quality α_j chosen by outlet j is decreasing in R, that is, the strategic substitution effect is exacerbated by a higher correlation in information production.

From the perspective of news consumers, when news stories are conditionally correlated, they become jointly less informative about the state. Not only is the posterior variance of news consumers larger, but also the marginal benefit from paying attention to reduce this variance is lower. In other words, a higher value of R tends to lower news consumers' attention and their reliance on the news stories. As dictated by Proposition 2, the feedback effect in turn reduces the quality of news outlets. These two mechanisms combined contribute to a decline in the total influence of the news market when the correlation is higher.

Suppose the correlation of news inputs indeed rises as a result of a larger number of news outlets being accommodated in the market; then, Proposition 6 predicts an additional mechanism that drives down news quality even further amid media proliferation.

5. Extension, Generalization, and Discussion

5.1. Partisan Preferences

In this model, we show that media proliferation can lead to a deterioration in news quality even in an environment without partisan bias. In reality, the partisan propensities of news consumers may impact their attention allocation, which in turn affects news quality in equilibrium. One particular relevant issue concerning our framework is confirmation bias—news consumers are more inclined to pay attention to media outlets with a similar political leaning (Chan and Suen 2008). In this section, we show that our key mechanisms—strategic substitution among outlets and strategic complementarity between outlets and consumers—are still at work even in the presence of such a behavioral bias.

We consider a setting that is otherwise identical to our model except that we allow consumers and outlets to possess two types of political inclinations. There are two types of outlets: they are otherwise identical (with the same weight ϕ assigned to ideological stance and the same precision of evidence γ) but differ in their political leanings. Type R outlets share a common "ideological position," $\xi_j = \overline{\xi} > 0$, while type L outlets share an opposite position, $\xi_j = -\overline{\xi} < 0$. Similarly, there are two types of news consumers. One type prefers to read stories from R-type outlets, and the other type prefers stories from L-type outlets.[16] To capture the partisan friction, we assume that the attention costs of reading from the two types of sources are different. If consumers read stories from their own type of news outlet, the marginal cost of attention is $p - \Delta > 0$ for some $\Delta > 0$; if they read stories from the other type of news outlet, the marginal cost of attention is $p + \Delta$. For simplicity, we assume that half of the outlets are R-type outlets and the other half are L-type outlets and that news consumers are split evenly into the two groups.

In this model, given the assumption of within-group homogeneity, consumers pay attention $\overline{z}$ and attach action weight (reliance) $\overline{\beta}$ to news outlets with aligned bias, and they pay attention $\underline{z}$ and attach action weight $\underline{\beta}$ to outlets with opposite bias. Each outlet provides the same news to both types, and its quality choice is α in a symmetric equilibrium. This model can be reduced to the original model when biased preference is unimportant for news consumption, i.e., $\Delta = 0$. Nevertheless, the main conclusion in the benchmark model remains valid in this extended model. The proof is provided in the online appendix.

Proposition 7. *Consider a symmetric equilibrium where the number of active outlets is below that maximum, i.e., $n < \overline{n}$, and consumers prefer reading news from outlets with the same political leaning, i.e., $\Delta > 0$. When the number of news outlets n rises, the news quality α falls.*

The news quality is monotonically decreasing with the total number of outlets in this economy even when consumers prefer reading news from outlets with the same political leaning. The mechanisms are the same as those analyzed in Section 4.2—strategic substitution among outlets and strategic complementarity between consumers and outlets.[17]

[16] Recall that $y_j = \alpha_j x_j + \alpha_{j0}$, where α_{j0} depends on ξ_j. Outlets with $\xi_j = \overline{\xi}$ produce systematically different news stories than outlets with $\xi_j = -\overline{\xi}$, and therefore, consumers of different types may develop different preferences over these two types of outlets.

[17] When the cost of consuming news from news outlets with opposite political leanings is pro-

5.2. A Generalized Objective Function

In our benchmark model with heterogeneous outlets, we assume that news outlets want to inform the public to take informed actions and that these outlets prefer that their news stories do not deviate from their own ideal stance or ideological positions. As analyzed earlier, the key mechanism that drives the main results in this model is the feedback mechanism that arises endogenously from the sender-receiver game and that renders the reduced-form marginal benefit of paying attention to a certain news outlet hump-shaped. The specifics of the objective function are not crucial. To demonstrate this point, we consider a more general setting, in which news outlets may also care whether their news stories are aligned with the truth (or the underlying state) so that the preferred editorial stance is state-dependent. To incorporate this concern, we consider the following utility function:

$$U_j = -\mathrm{E}\left[(Q-\theta)^2 + \phi_j\left(y_j - \left(\lambda\theta + (1-\lambda)\xi_j\right)\right)^2 \,\middle|\, x_j\right]. \tag{17}$$

The term $\lambda\theta + (1-\lambda)\xi_j$ in equation (17) represents outlet j's preferred editorial stance regarding news issue θ. If $\lambda = 0$, this utility function reduces to that in the benchmark model. If $\lambda = 1$, the news outlets' ideological positions do not matter for their news production.

Lemma 5. *Suppose $\lambda \in [0,1]$. Considering that $\hat{\boldsymbol{\alpha}}$ and $\hat{\boldsymbol{\beta}}$ are endogenously determined in the sender-receiver game, a reduced-form first-order condition for z_j is given by:*

$$\frac{\hat{\beta}_j(z_j; H)}{z_j} = \sqrt{\frac{p}{\chi}}. \tag{18}$$

If $\phi_j \geq 1-\gamma_j$, then for fixed H, $\hat{\beta}_j(z_j; H)$ is increasing in z_j and $\hat{\beta}_j(z_j; H)/z_j$ is quasi-concave in z_j.

Equation (18) corresponds to the key equation (15) of the benchmark model. This general case does not admit close form solutions. However, we show that the two key counteracting effects that give rise to a hump-shaped reduced-form marginal benefit curve, are still present in this generalized model: fixing H, $\hat{\beta}_j(z_j; H)$ increases in z_j (the feedback effect), and $1/z_j$ decreases in z_j (diminishing returns).

Consider the case where λ is small, i.e., outlet j assigns a large weight (i.e., $1-\lambda$) to its own ideological position in the preferred editorial stance. By continuity, the

hibitively high, a perfect segregation can arise in our model (i.e., $\underline{\beta} = \underline{z} = 0$). Flaxman, Goel, and Rao (2016) provides empirical evidence of segregation in news consumption. However, it does not prevent our mechanism from working. If a type-L (or R) outlet enters the market, the news quality of L (or R) outlets falls.

model with this generalized objective function behaves in a similar fashion as in our benchmark model. Consider the case that λ is large. Figure 6 (in the online appendix) provides a numerical example in which the reduced-form marginal benefit $\hat{\beta}(z;H)/z$ is indeed hump-shaped in z with a large value $\lambda = 0.7$.[18]

5.3. Active Outlets: Entry Cost and Subscription Fees

Two prominent features of the news market are absent in our model. First, in sections 3 and 4, our equilibrium analysis is based on the premise that a fixed group of outlets are active in the market. In such a setting, we study the effects of exogenous entry before the market reaches saturation (i.e., no additional outlets can obtain attention from news consumers). However, in actuality, the size of the active group should be endogenous and determined by economic incentives.[19] Second, news outlets may charge subscription fees from news consumers, which we do not allow in our benchmark model. In the following, we show that our analysis can be extended to include the entry decisions of news firms and that our model mechanisms remain robust even when we allow news outlets to charge subscription fees for their news products.

For simplicity we assume all outlets are homogenous so that the market structure can be summarized by the number of outlets. Suppose there is an additional stage before the sender-receiver game, where outlets need to decide whether they enter the market or not. If they enter the market, they expect to obtain a certain amount of attention that they can monetize to raise revenue, e.g., turning attention into advertising revenue. Let the revenue received by a news outlet be qz, where q is the value per unit of attention it attracts. An outlet has to pay an entry cost F to enter the market. The following corollary summarizes the determination of the size of the active group of outlets in such a setting.

Corollary 1. *If the entry cost is lower than a threshold (i.e., $F < \hat{F}$), the number of active outlets in this market is $\overline{n}$ (i.e., the maximum number that can be supported), and each active outlet receives a positive profit in equilibrium. If the entry cost is larger than the threshold (i.e., $F \geq \hat{F}$), the number of active media in the market is lower than $\overline{n}$, and each outlet receives zero profit in equilibrium.*

Part (i) of Lemma 4 shows that the amount of attention $z^*(n)$ received by each outlet would drop when the number of active outlets n increases. Therefore, the revenue received by each outlet monotonically decreases in n. Let $\hat{F} = qz^*(\overline{n})$. If the fixed

[18]In fact, for any value of λ, the counterpart to Lemma 1 still holds under some restrictions on parameter values. We restrain from providing a compete characterization since the details do not enrich our key insights.

[19]Proposition 5 also discusses the effects of changes in attention cost on the media market when the number of active news outlets always adjusts to reach the upper bound, but the economic incentives behind such adjustments are not modeled explicitly.

entry cost F is below $\hat{F}$, then the market can accommodate $\overline{n}$ outlets, following Part (ii) of Lemma 4. Interestingly, all the active outlets make positive profit in this case, and the "zero-profit condition" does not apply. Even if there is no entry barrier to the news industry, new firms may not be able to enter the market when all the existing firms earn positive profits. If the fixed entry cost F is greater than $\hat{F}$, then the number of active outlets in the equilibrium is smaller than $\overline{n}$ and is equal to the largest n such that $qz^*(n) \geq F$, and the zero-profit condition applies. In this case, the market is not saturated yet, but the attention each outlet receives is so small that it just breaks even.

Our results suggest that a declining entry cost F can be another obvious contributor to media proliferation. This model predicts that consumers spend less time on each outlet and that the news quality of outlets falls when entry cost decreases.

We can further extend the model to allow each outlet to charge a subscription fee from news consumers. Suppose that each active news outlet charges a subscription fee S. A free-entry equilibrium is given by a pair (n^*, S^*) such that

$$qz^*(n^*) + S^* = F,$$
$$S^* = V^*(n^* + 1) - V^*(n^*).$$

The first equation is the zero-profit condition when allowing for subscription fees: $qz^*(n^*) + S^*$ is one outlet's revenue when there are n^* outlets in the industry and when it charges a subscription fee of S^*. In the second equation, $V^*(n)$ stands for consumers' equilibrium utility (before paying subscription fees) when there are n news outlets in the industry, i.e.,

$$V^*(n) = -(1 - H^*(n))v_\theta - npz^*(n),$$

where $H^*(n)$ is the equilibrium H when there are n outlets. In this equilibrium, consumers' net equilibrium utility is $V^*(n^*) - nS^*$.

To see why the second equation is a necessary equilibrium condition, consider a potential entrant. Suppose that it enters the market and that other outlets do not change their subscription fees, the subscription fee S^e that this entrant can charge cannot exceed

$$S^e_{\max} = [V(n^* + 1) - nS^*] - [V(n^*) - nS^*].$$

Thus, we must have $S^e \leq S^e_{\max} = S^*$. The profit that this entrant can expect to obtain is $qz(n^* + 1) + S^e < qz(n^*) + S^* = F$. Therefore, the potential entrant cannot profitably enter the industry, and (n^*, S^*) is a free-entry equilibrium.

If the n^* that satisfies the above condition is larger than the upper bound $\overline{n}$, then we have $n = \overline{n}$ in equilibrium. The corresponding equilibrium subscription fee is $S = V^*(\overline{n}) - V^*(\overline{n} - 1)$. An outlet that charges a subscription fee higher than this level will not be read by any news consumer.

In this extended model with endogenous entry, we can pin down both the number of outlets n^*, the attention-based revenue qz^*, and subscription-based revenue S^*. The model mechanisms that we propose in this paper are still intact.

6. Conclusion

We study a model in which consumers allocate attention among various information suppliers, which in turn has an impact on the quality choices of those suppliers. Our work contributes to the literature on information acquisition and sender-receiver games. We extend the former by allowing the underlying information structure of signals to be chosen in response to the information acquisition of receivers. We enrich the latter by developing a workable approach to characterize sender-receiver games in which a large number of heterogeneous senders who possess nonidentical private information attempt to influence a set of decision makers.

We study such a feedback mechanism in the context of the news media market and use this model to reconcile puzzling trends in this market. When attention is abundant and cheap, a larger number of news outlets can survive in the market. However, the proliferation of news outlets can lead to a decline in news quality. We acknowledge that other features of the media market may contribute to the observed trends. While we do not attempt to provide a comprehensive model that incorporates all features of the media industry, we do show that our mechanism is robust and may complement other established mechanisms to offer a realistic analysis of the media market.

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Appendix

We first rewrite equations (8) and (10) in a different form to emphasize that the quality of and the reliance on news outlet j depend on other news outlets only through the aggregate informativeness H of the news industry. Holding H fixed, equation (33) below implies that the influence of news outlet j increases when its quality is higher and when consumers pay more attention to it. Equation (34) implies that the influence of news outlet j increases when consumers rely on it more and when the expressive motive decreases. Both equations imply that news outlet j' s influences decline when the total influence H rises.

Lemma 6. *News consumers' reliance β_j and the news outlet's quality choice α_j satisfy the following:*

$$\alpha_j\beta_j = \frac{1-H}{\frac{1-\gamma_j}{\gamma_j} + \frac{\chi}{z_j\alpha_j^2 v_\theta}} =: F_1(\alpha_j; H, z_j), \tag{19}$$

$$\alpha_j\beta_j = \frac{1-H}{\frac{1-\gamma_j}{\gamma_j} + \frac{\phi_j}{\gamma_j\beta_j^2}} =: F_2(\beta_j; H, \phi_j), \tag{20}$$

Proof. Multiplying both sides of equation (8) by α_j and summing over all j gives $H = \sum_k \tau_k/(1+\sum_k \tau_k)$. Use this relationship to eliminate $\sum_k \tau_k$ from equation (8) and substituting the definition of τ_j into this equation gives equation (33).

For $j = 1, \ldots, J$, let $t_j := \gamma_j\beta_j^2/(\beta_j^2 + \phi_j)$. We multiply equation (10) by β_j and subtract $t_j\alpha_j\beta_j$ from both sides to obtain the following: $(1-t_j)\alpha_j\beta_j = t_j(1-\sum_k \alpha_k\beta_k)$. Substituting the definition of t_j into this equation gives equation (34). □

Proof of Proposition 1. Comparing the two equations in Lemma 6 shows that

$$\frac{\chi}{z_j\alpha_j^2 v_\theta} = \frac{\phi_j}{\gamma_j\beta_j^2}.$$

Hence,

$$\alpha_j = \frac{\gamma_j}{\phi_j}(1-h_j)\beta_j,$$

where $1 - h_j = \sqrt{\phi_j\chi/(z_j\gamma_j v_\theta)}$. Using this relationship to eliminate α_j from equation (34) allows us to solve for β_j:

$$\hat{\beta}_j^2 = \frac{(h_j - H)\phi_j}{(1-\gamma_j)(1-h_j)}.$$

Substituting $\alpha_j = \beta_j \gamma_j (1 - h_j)/\phi_j$ with $\beta_j = \hat{\beta}_j$ gives

$$\hat{\alpha}_j^2 = \frac{\gamma_j^2 (h_j - H)(1 - h_j)}{(1 - \gamma_j)\phi_j}.$$

Multiplying $\hat{\alpha}_j^2$ by $\hat{\beta}_j^2$ and taking the square root yields

$$\hat{\alpha}_j \hat{\beta}_j = \frac{\gamma_j (h_j - H)}{1 - \gamma_j}.$$

When we sum the last equation over all j, the left-hand side is equal to H. Solving for H from that equation yields:

$$H = \frac{\sum_j \frac{\gamma_j}{1-\gamma_j} h_j}{1 + \sum_j \frac{\gamma_j}{1-\gamma_j}}.$$

The above solution is valid if and only if $h_j - H > 0$. Suppose $h_j > 0$ and $G = \{j\}$. Then, $h_j - H_G$ is indeed positive.

Finally, when $\beta_j = 0$, the reporting strategy (9) implies that $\alpha_j = 0$ is the best response. Moreover, when $\alpha_j = 0$, the news story $\hat{y}_j$ is uninformative with $\tau_j = 0$. The action rule (7) implies that $\beta_j = 0$ is the best response. Hence, for any outlet $j \in \{1, \ldots, J\}$, a pair $(\hat{\alpha}_j, \hat{\beta}_j) = (0, 0)$ can also be part of equilibrium. □

Proof of Lemma 1. Substituting equation (8) into the first-order condition (14) yields

$$\frac{\beta_j}{z_j} - \sqrt{\frac{p}{\chi}} = 0.$$

From the definition of $h_j(z_j)$, we have $z_j = \phi_j \chi / (\gamma_j v_\theta (1 - h)^2)$. Substituting this into the first-order condition and using the $\hat{\beta}_j$ from Proposition 1 for β_j, we obtain

$$\frac{\gamma_j^2 v_\theta^2}{(1 - \gamma_j)\phi_j \chi}(h_j - H)(1 - h_j)^3 = p.$$

It is routine to show that, for a given H, the left-hand side of the above equation is concave in h_j and reaches a maximum at $h_j = (1 + 3H)/4$. □

Proof of Proposition 2. Comparing the value of $\hat{\alpha}_j$ specified in Proposition 1 to the key equation (15) in Lemma 1, we see that

$$\hat{\alpha}_j = \frac{\sqrt{p\chi}}{v_\theta (1 - h_j(z_j))}.$$

Since $h_j(\cdot)$ is increasing, a higher z_j raises $\hat{\alpha}_j$. In the main text, we showed that $z_j = \hat{\beta}_j \sqrt{\chi / p}$. Thus, a higher z_j also raises $\hat{\beta}_j$. $\square$

Proof of Lemma 2. By Lemma 1, the left-hand side of equation (15) reaches a maximum at $h_j = (1 + 3H)/4$, with a maximal value of

$$\frac{27}{256} \frac{\gamma_j^2 v_\theta^2}{(1-\gamma_j)\phi_j \chi} (1-H)^4,$$

which is decreasing in H. There exists an $\overline{H}^j$ such that if $H > \overline{H}^j$, the maximal value is lower than p, in which case there is no z_j that will satisfy equation (15). Since the left-hand side of equation (15) is decreasing in h_j for $h_j > (1+3H)/4$ and in H, the fact that $D(\cdot)$ is decreasing follows from the implicit function theorem. Similarly, one can use the implicit function theorem to show that $D_j(H)$ decreases in p.

At $H = \overline{H}^j$, the value of $D_j(\overline{H}^j)$ is determined by the solution in z_j to the equation $h_j(z_j) = (1 + 3\overline{H}^j)/4$. Hence, $1 - h_j(z_j) = 3(1 - \overline{H}^j)/4 > 0$, which implies $z_j = D_j(\overline{H}^j) > 0$. For $H > \overline{H}^j$, we have $D_j(H) = 0$. Hence, $D_j(\cdot)$ is discontinuous. $\square$

Proof of Proposition 3. Fix a set $G \subseteq \{1, \ldots, J\}$. An outlet j can belong to G only if $H \leq \overline{H}_G = \min_{j \in G} \overline{H}^j$. For $H \in [0, \overline{H}_G]$, $\kappa_G(\cdot)$ is well defined. By Lemma 2, $D_j(H)$ decreases in H and in p. Since $\kappa_G(H)$ increases in $D_j(H)$, we establish that $\kappa_G(H)$ is decreasing in H and in p for $H \in [0, \overline{H}_G]$.

Suppose there are n firms in the set G. Let $\overline{\gamma} := \max_{j \in G} \gamma_j$, and define

$$\overline{H} := \frac{n \frac{\overline{\gamma}}{1-\overline{\gamma}}}{1 + n \frac{\overline{\gamma}}{1-\overline{\gamma}}}.$$

If $\overline{H} \leq \overline{H}_G$, then for $j \in G$, the solution to the key equation (15) implies that $h_j < 1$. Hence,

$$\kappa_G(\overline{H}_G) = \frac{\sum_{j \in G} \frac{\gamma_j}{1-\gamma_j} h_j}{1 + \sum_{j \in G} \frac{\gamma_j}{1-\gamma_j}} < \frac{n \frac{\overline{\gamma}}{1-\overline{\gamma}}}{1 + n \frac{\overline{\gamma}}{1-\overline{\gamma}}} = \overline{H} \leq \overline{H}_G.$$

Moreover, $\kappa_G(0) > 0$. Therefore, there exists a unique $H_G^* \in (0, \overline{H})$ such that $\kappa_G(H_G^*) = H_G^*$.

The existence of H_G^* established above requires $\overline{H} \leq \overline{H}_G$. Recall from the proof of Lemma 2 that $\overline{H}^j$ is defined by the solution to the equation:

$$\frac{27}{256} \frac{\gamma_j^2 v_\theta^2}{(1-\gamma_j)\phi_j \chi} (1 - \overline{H}^j)^4 = p.$$

Hence, $\overline{H}^j$ decreases with p and can be arbitrarily close to 1 when p is close to 0. For p sufficiently small, we have $H \leq \overline{H}_G$, and an equilibrium H_G^* exists. □

Proof of Lemma 3. Since $\overline{H}_G = \min_{j \in G} \overline{H}^j$, $G' \subset G$ implies $\overline{H}_{G'} \geq \overline{H}_G$. Hence, for any H such that $\kappa_G(H)$ is well defined, $\kappa_{G'}(H)$ is also well defined. Furthermore, since $h_j > 0$ for $j \in G$, we have $\kappa_{G'}(H) < \kappa_G(H)$ for every $H \leq \overline{H}_G$. Thus,

$$\kappa_{G'}(H_G^*) < \kappa_G(H_G^*) = H_G^*.$$

Because $\kappa_G(0) > 0$, there exists $H_{G'}^*$ such that $\kappa_{G'}(H_{G'}^*) = H_{G'}^*$. Moreover, $H_{G'}^* < H_G^*$.

For the second part of the lemma, suppose there exists $k \notin G$ with $\overline{H}^k < H_G^*$. Let $G'' = G \cup \{k\}$. Then, $\kappa_{G''}(H)$ is well defined only for $H \leq \overline{H}^k$, with

$$\kappa_{G''}(\overline{H}^k) > \kappa_G(\overline{H}^k) > \kappa_G(H_G^*) = H_G^* > \overline{H}^k.$$

Since $\kappa_{G''}(0) > 0$ and $\kappa_{G''}(\cdot)$ is decreasing on $[0, \overline{H}^k]$, there does not exist a fixed point of $\kappa_{G''}(\cdot)$. □

Proof of Proposition 4. Let $G = \{1, \ldots, J\}$ and $G'' = \{1, \ldots, J+1\}$. If an equilibrium with active media group G'' exists (i.e., the industry has not reached a saturation point), Lemma 3 implies that $H_{G''}^* > H_G^*$.

For each $j \in G$, $z_j^* = D_j(H)$, where H is the equilibrium total influence. Since $D_j(\cdot)$ is decreasing, a higher value of H implies that z_j^* falls. Moreover, Proposition 2 implies that a lower z_j^* leads to a lower α_j^* and β_j^*. □

Proof of Lemma 4. Let n be the number of firms in an active media group G. From the definition of H_G, we have

$$h - H_G = \frac{h}{1 + n\frac{\gamma}{1-\gamma}}.$$

Substituting this equation into the key equation (15), we obtain:

$$\frac{\gamma^2 v_\theta^2}{(1-\gamma)\chi\phi} \frac{h(1-h)^3}{1 + n\frac{\gamma}{1-\gamma}} = p.$$

By the implicit theorem, we have

$$\frac{\mathrm{d}h}{\mathrm{d}n} = \frac{p\chi\phi}{(1-h)^2(1-4h)\gamma v_\theta^2} < 0.$$

The inequality holds since $h > 1/4$ (shown by Lemma 1). Since h increases in z, Part (i) is proven.

The maximum value of $h(1-h)^3$ is $27/256$. Therefore, an upper bound on the number of active firms that can be supported in any equilibrium is the largest integer $\overline{n}$ such that

$$\frac{27}{256}\frac{\gamma^2 v_\theta^2}{(1-\gamma)\phi\chi}\frac{1}{1+\overline{n}\frac{\gamma}{1-\gamma}} \geq p. \tag{21}$$

It is obvious that such $\overline{n}$ decreases in p, which shows Part (ii). □

Proof of Proposition 5. Ignoring the integer constraint for $\overline{n}$, the proof of Lemma 4 shows that $\overline{n}$ is determined by equation (21). Thus, $\overline{n}$ increases as p falls. Moreover, in an equilibrium with $n = \overline{n}$, $h(1-h)^3$ must be at a maximum, which implies that $h(z) = 1/4$. Because $h(z)$ is constant as p decreases, z is also fixed as p decreases, implying that total attention $\overline{n}z$ must rise when p falls. In this equilibrium, total informativeness is

$$H = \frac{\overline{n}\frac{1-\gamma}{\gamma}h(z)}{1+\overline{n}\frac{1-\gamma}{\gamma}}.$$

Since $h(z)$ is fixed at $1/4$, total informativeness H increases as $\overline{n}$ increases. Furthermore, Proposition 1 shows that an increase in H while holding $h(z)$ fixed leads to a lower α and a lower β. Thus, a lower p reduces both α and β in this equilibrium. □

Proof of Proposition 6. Following the proof of Lemma 6, we can show that news consumers' reliance β_j and the news outlet's quality choice α_j satisfy:

$$\alpha_j\beta_j = \frac{1}{R}\frac{1-RH}{\frac{1-R\gamma_j}{R\gamma_j}+\frac{\phi_j}{R\gamma_j\beta_j^2}},$$
$$\alpha_j\beta_j = \frac{1}{R}\frac{1-RH}{\frac{1-R\gamma_j}{R\gamma_j}+\frac{\chi}{Rz_j\alpha_j^2 v_\theta}},$$

where $H = \sum_k \alpha_k\beta_k$. These two equations imply

$$\alpha_j = \frac{\gamma_j}{\phi_j}(1-h_j)\beta_j,$$

where h_j is defined as in equation (11). Using this relationship to eliminate α_j from the first equation above allows one to solve for β_j:

$$\hat{\beta}_j^2 = \frac{(h_j - RH)\phi_j}{(1-R\gamma_j)(1-h_j)}.$$

From this equation, we also obtain:

$$\begin{aligned}\hat{\alpha}_j^2 &= \frac{\gamma_j^2(h_j - RH)(1-h_j)}{(1-R\gamma_j)\phi_j},\\ \hat{\alpha}_j\hat{\beta}_j &= \frac{\gamma_j(h_j - RH)}{1-R\gamma_j}.\end{aligned}$$

Summing the last equation over j and solving for H, we obtain:

$$H = \frac{1}{R}\frac{\sum_j \frac{R\gamma_j}{1-R\gamma_j}h_j}{1+\sum_j \frac{R\gamma_j}{1-R\gamma_j}}.$$

Under Gaussian updating, the posterior variance is given by $\sigma_\theta^2(1-\sum_j \alpha_j\beta_j)$. Therefore, news consumers allocate attention by maximizing:

$$V = -\sigma_\theta^2\left(1 - \frac{1}{R}\frac{\sum_j \tau_j}{1+\sum_j \tau_j}\right) - \sum_j pz_j.$$

The first-order condition is:

$$\frac{1}{R}\frac{\tau_j}{1+\sum_j \tau_j}\frac{1}{z_j\alpha_j} = \sqrt{\frac{p}{\chi}}.$$

The left-hand side of this equation is simply $\hat{\beta}_j/z_j$. Using the expression for $\hat{\beta}_j$ obtained earlier and the definition of h_j to write z_j in terms of h_j, the first-order condition can be rewritten as the following key equation:

$$\frac{\gamma_j^2 v_\theta^2}{(1-R\gamma_j)\phi_j\chi}(h_j(z_j) - RH)(1-h_j(z_j))^3 = p.$$

Define $D_j(H)$ as the larger solution to z_j in this key equation (and let $D_j(H) = 0$ if it has no solution). The derivative of the left-hand side of the above with respect to R has the same sign as $\gamma_j h_j - H$. In a symmetric equilibrium with n news outlets,

$$\gamma h - H = \frac{-(n-1)\gamma h}{1+n\frac{R\gamma}{1-R\gamma}} < 0,$$

(where we have dropped the subscript for media firms). Moreover, the derivative of the left-hand side of the key equation with respect to z_j is negative at the larger root. It follows from the implicit function theorem that $\partial D_j/\partial R < 0$.

In a symmetric equilibrium, let

$$\kappa(H) = \frac{1}{R}\left(\frac{n\frac{R\gamma}{1-R\gamma}\left(1-\sqrt{\frac{\phi\chi}{D(H)\gamma v_\theta}}\right)}{1+n\frac{R\gamma}{1-R\gamma}}\right).$$

One can verify that

$$\frac{\partial\kappa}{\partial R} = -(n-1)n\left(\frac{\frac{\gamma}{1-R\gamma}}{1+n\frac{R\gamma}{1-R\gamma}}\right)^2\left(1-\sqrt{\frac{\phi\chi}{D(H)\gamma v_\theta}}\right) < 0.$$

Furthermore, we have $\partial\kappa/\partial D > 0$. Therefore,

$$\frac{d\kappa}{dR} = \frac{\partial\kappa}{\partial R} + \frac{\partial\kappa}{\partial D}\frac{\partial D}{\partial R} < 0.$$

We conclude that the fixed point of $\kappa(\cdot)$ must fall when R increases, i.e., H^* decreases. Because the number of firms is fixed, the influence of each firm, $\alpha^*\beta^* = H^*/n$, also decreases.

To show that z^* must fall when R increases, suppose the opposite is true (i.e., z^* increases). Recall that the first-order condition requires that β_j^* is proportional to z^*. Hence, β_j^* increases. Moreover, we can use the formula for α_j^2 and the key equation to show that

$$\alpha_j = \frac{\sqrt{p\chi}}{v_\theta(1-h_j)}.$$

A higher z^* means that $h_j(z^*)$ is higher; therefore, α_j^* increases. However, when both α_j^* and β_j^* increase, total informativeness H^* must rise. This finding contradicts our earlier conclusion that H^* falls, so we conclude that z^* must fall. Since an increase in z_j^* raises h_j, the formulas for α_j^2 and β_j^2 imply that α_j^* and β_j^* must both fall. □

Online Appendix to "Competition for Attention and News Quality"

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(Not intended for publication)

A. Supplementary Materials for Section 5.1

Proof of Proposition 7. Aggregate action is

$$Q = \beta_0 + \sum_k 0.5(\overline{\beta}_k + \underline{\beta}_k)\hat{y}_k.$$

Let $\beta = 0.5(\overline{\beta}_k + \underline{\beta}_k)$. Substituting Q into the objective function of news outlet j and performing the same exercise as in the base model, we obtain:

$$\alpha\beta = \frac{1-H}{\frac{1-\gamma}{\gamma} + \frac{\phi}{\gamma\beta^2}}, \tag{22}$$

where $H = n\alpha\beta$.

On the reader's side, consider a consumer who prefers type-R outlets. This consumer exhibits reliance $\overline{\beta}$ on stories from type-R outlets. We have

$$\alpha\overline{\beta} = \frac{\overline{\tau}}{1 + 0.5(\overline{\tau} + \underline{\tau})n}, \tag{23}$$

where

$$\overline{\tau} = \frac{1}{\frac{1-\gamma}{\gamma} + \frac{\chi}{\overline{z}\alpha^2 v_\theta}}, \tag{24}$$

$$\underline{\tau} = \frac{1}{\frac{1-\gamma}{\gamma} + \frac{\chi}{\underline{z}\alpha^2 v_\theta}}. \tag{25}$$

For stories from outlets with the opposite bias, this consumer exhibits reliance $\underline{\beta}$ on their stories, where

$$\alpha\underline{\beta} = \frac{\underline{\tau}}{1 + 0.5(\overline{\tau} + \underline{\tau})n}. \tag{26}$$

The case for the opposite consumer who prefers type L outlets is analogous. If we let $\tau = 0.5(\overline{\tau} + \underline{\tau})$, then these equations can be combined to obtain:

$$\alpha\beta = \frac{\tau}{1 + n\tau}.$$

Because $H = n\alpha\beta$, we have

$$1 - H = \frac{1}{1 + 0.5(\overline{\tau} + \underline{\tau})n}. \tag{27}$$

Now, consider the determination of $\overline{z}$ and $\underline{z}$. We use the new cost function, i.e., the marginal cost of attention is $p - \Delta$ for aligned media or $p + \Delta$ for misaligned media. The first-order conditions for $\overline{z}$ and $\underline{z}$ are:

$$\left(\frac{\overline{\tau}}{1 + J\tau}\right)^2 \frac{1}{\overline{z}^2\alpha^2} - \frac{p - \Delta}{\chi} = 0,$$
$$\left(\frac{\underline{\tau}}{1 + J\tau}\right)^2 \frac{1}{\underline{z}^2\alpha^2} - \frac{p + \Delta}{\chi} = 0.$$

These expressions can also be written as

$$\frac{\overline{\beta}}{\overline{z}} = \sqrt{\frac{p - \Delta}{\chi}}, \tag{28}$$
$$\frac{\underline{\beta}}{\underline{z}} = \sqrt{\frac{p + \Delta}{\chi}}. \tag{29}$$

Equations (22) to (29) give eight equations in eight unknowns, $(\alpha, \underline{\beta}, \overline{\beta}, \underline{\tau}, \overline{\tau}, \underline{z}, \overline{z}, H)$.

We use $H = n\alpha\beta$ to substitute β from equation (22) and obtain

$$\phi\alpha^2 = \gamma\frac{H(1 - H)}{n} - (1 - \gamma)\frac{H^2}{n^2}. \tag{30}$$

From equation (27), equation (23) can be written as $\alpha\overline{\beta} = (1 - H)\overline{\tau}$. Using the definition of $\overline{\tau}$ in equation (24), we have

$$1 - H = \alpha\overline{\beta}\frac{1 - \gamma}{\gamma} + \frac{\chi}{\alpha v_\theta}\frac{\overline{\beta}}{\overline{z}}.$$

Similarly,

$$1 - H = \alpha\underline{\beta}\frac{1 - \gamma}{\gamma} + \frac{\chi}{\alpha v_\theta}\frac{\underline{\beta}}{\underline{z}}.$$

Summing these two equations and using (28) and (29), we have

$$1 - H = \alpha\beta\frac{1 - \gamma}{\gamma} + \frac{\sqrt{\chi}}{\alpha v_\theta}k,$$

where $k \equiv 0.5(\sqrt{p-\Delta}+\sqrt{p+\Delta})$. Using $\alpha\beta = H/n$, this equation further reduces to

$$H = \frac{1 - \frac{\sqrt{\chi}}{\alpha v_\theta}k}{1 + \frac{1}{n}\frac{1-\gamma}{\gamma}}. \tag{31}$$

Combining equations (30) and (31), we have

$$(n\gamma + 1 - \gamma)v_\theta^2 \phi \alpha^4 - \gamma^2 v_\theta \sqrt{\chi} k\alpha + \gamma^2 \chi k^2 = 0. \tag{32}$$

The left-hand side of (32) decreases and then increases in α. There are two roots, and we focus on the larger one because the equilibrium corresponding to the larger root is locally stable. This focus corresponds to the convention in the main text of picking the larger root for the $D_j(\cdot)$ function when there are two solutions to the key equation (15).

Differentiating equation (32) with respect to n, we have

$$\left[4(n\gamma + 1 - \gamma)v_\theta^2 \phi \alpha^3 - \gamma^2 v_\theta \sqrt{\chi} k\right]\frac{\partial \alpha}{\partial n} = -\gamma v_\theta^2 \phi \alpha^4.$$

The term in brackets is positive since the left-hand-side of equation (32) is increasing in α at the larger root. Thus, $\partial\alpha/\partial n < 0$. □

B. Supplementary Materials for Section 5.2

Using the generalized utility function for news outlet j, we can perform the same exercise as in the benchmark model to derive its reporting strategy. This process leads to

$$\alpha_j \beta_j = \frac{\gamma_j \beta_j (\beta_j (1-H) + \lambda \phi_j)}{(1-\gamma_j)\beta_j^2 + \phi_j} =: F_1(\beta_j) \tag{33}$$

On the reader's side, the optimal action rule is derived from Bayes' rule and implies

$$\alpha_j \beta_j = \frac{1-H}{\frac{1-\gamma_j}{\gamma_j} + \frac{\chi}{z_j \alpha_j^2 v_\theta}} =: F_2(\alpha_j; z_j). \tag{34}$$

We drop the subscript j whenever it is unlikely to cause confusion. We first show that $F_1' \in (0, 2\alpha)$ if $\phi > 1-\gamma$. Taking the derivative,

$$F_1' = \frac{2\beta\gamma(1-H) + \gamma\lambda\phi}{(1-\gamma)\beta^2 + \phi} - \frac{2\beta(1-\gamma)}{(1-\gamma)\beta^2 + \phi}F_1 < 2\left(\frac{\beta\gamma(1-H) + \gamma\lambda\phi}{(1-\gamma)\beta^2 + \phi}\right) = \frac{2}{\beta}F_1 = 2\alpha.$$

We can also express the derivative explicitly as:

$$F_1' = \frac{\gamma\phi\left(2\beta(1-H)+\lambda\phi-(1-\gamma)\lambda\beta^2\right)}{\left((1-\gamma)\beta^2+\phi\right)^2}.$$

A sufficient condition for $F_1' > 0$ is $\phi > 1-\gamma$.

We next show that $F_2' \in (0, 2\beta)$. Taking the derivative,

$$F_2' = \frac{1-H}{\left(\frac{1-\gamma}{\gamma}+\frac{\chi}{z\alpha^2 v_\theta}\right)^2}\frac{\chi}{zv_\theta}\frac{2}{\alpha^3} = \frac{F_2}{\alpha}\frac{2\frac{\chi^2}{z\alpha^2\sigma_\theta^2}}{\frac{1-\gamma}{\gamma}+\frac{\chi^2}{z\alpha^2\sigma_\theta^2}} < 2\frac{F_2}{\alpha} = 2\beta.$$

The fact that $F_2' > 0$ is obvious.

Proof of Lemma 5. For given z_j and H, equations (33) and (34) give two equations with two unknowns. Let $\hat{\alpha}_j(z_j; H)$ and $\hat{\beta}_j(z_j; H)$ represent the solution to this equation system. Implicit differentiation gives

$$\frac{\partial\hat{\beta}_j(z_j;H)}{\partial z_j} = \frac{\beta_j F_{2z}}{\alpha_j\beta_j - (\alpha_j - F_1')(\beta_j - F_2')}.$$

From equation (34), it is clear that $F_{2z} > 0$. Furthermore, since $F_1' \in (0, 2\alpha_j)$ (when $\phi_j > 1-\gamma_j$) and $F_2' \in (0, 2\beta_j)$, the denominator is also positive. This result establishes that $\hat{\beta}_j(\cdot; H)$ is increasing.

We next show that $\hat{\beta}_j(z_j; H)/z_j$ is single-crossing from above. Substituting equation (33) into (34) yields

$$\left(\frac{1-\gamma_j}{\gamma_j}+\frac{\chi}{z_j\alpha_j^2 v_\theta}\right)\gamma_j\beta_j(\beta_j(1-H)+\lambda\phi_j) = (1-H)\left((1-\gamma_j)\beta_j^2+\phi_j\right).$$

This equation simplifies to:

$$\chi\gamma_j\beta_j(\beta_j(1-H)+\lambda\phi_j) = z_j\alpha_j^2 v_\theta\phi_j\left(1-H-(1-\gamma_j)\beta_j\lambda\right)$$

Multiply both sides by β_j^2 and use equation (33) again:

$$\chi\gamma_j\beta_j^3(\beta_j(1-H)+\lambda\phi_j) = z_j v_\theta\phi_j\left(1-H-(1-\gamma_j)\beta_j\lambda\right)\left(\frac{\gamma_j\beta_j(\beta_j(1-H)+\lambda\phi_j)}{(1-\gamma_j)\beta_j^2+\phi_j}\right)^2$$

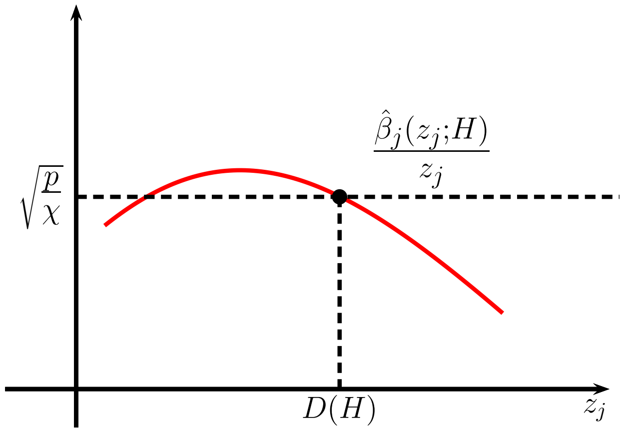

Figure 6. *When the objective function takes the general form (i.e., equation (17)), the reduced-form marginal benefit of paying attention increases and then decreases in z_j. The set of parameters used in this numerical example are $\gamma = 0.5$, $\chi = 0.3$, $v_\theta^2 = 1$, $\phi_j = 0.5$, $\lambda = 0.7$, $H = 0.5$ and $p = 1.2$.*

This equation simplifies to

$$\frac{\beta_j}{z_j} = \frac{\gamma_j v_\theta \phi_j}{\chi} \left(\frac{(1 - H - (1-\gamma_j)\beta_j\lambda)\left(\beta_j(1-H) + \lambda\phi_j\right)}{((1-\gamma_j)\beta_j^2 + \phi_j)^2} \right) \tag{35}$$

Denote the term in parentheses on the right-hand side of (35) by Ω. We have

$$\frac{\partial\Omega}{\partial\beta_j} = \frac{\gamma_j v_\theta \phi_j}{\chi((1-\gamma_j)\beta_j^2 + \phi_j)^2} \left((1-H)^2 - (1-\gamma_j)\lambda^2\phi_j - 4(1-\gamma_j)\beta_j \left((1-\gamma_j)\beta_j^2 + \phi_j \right) \Omega \right) \tag{36}$$

At the point where $\partial\Omega/\partial\beta_j = 0$, the second derivative is

$$\frac{\partial^2\Omega}{\partial\beta_j^2} = \frac{\gamma_j v_\theta \phi_j}{\chi((1-\gamma_j)\beta_j^2 + \phi_j)^2} \left(-4(1-\gamma_j) \left(3(1-\gamma_j)\beta_j^2 + \phi_j \right) \Omega \right) < 0.$$

This result shows that $\partial\Omega/\partial\beta_j$ is single-crossing from above in β_j, which means that Ω is quasi-concave in β_j. Since we have already established that $\hat{\beta}_j(z_j; H)$ increases in z_j, Ω is quasi-concave in z_j. Therefore, $\hat{\beta}_j(z_j; H)/z_j$ is quasi-concave in z_j. □

Suppose that the term $(1-\gamma_j)\lambda^2\phi_j$ is small. An inspection of equation (36) shows that the right-hand side of equation (36) is positive when β_j is small and negative when β_j is large. That is, β_j/z_j is increasing and then decreasing. Figure 6 illustrates an example where $\lambda = 0.7$.