Time Scarcity and the Market for News*

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Abstract

We develop a theory of news coverage in environments of information abundance. News consumers are time-constrained and browse through news items that are available across competing outlets, choosing which ones to read or skip. Media firms are aware of consumers’ preferences and constraints, and decide on rankings of news items that maximize their profits. We find that, even when readers and outlets are rational and unbiased and when markets are competitive, readers may read more than they would like to, and the stories they read may be significantly different from the ones they prefer. Next, we derive implications on diverse aspects of new and traditional media. These include a rationale for tabloid news, a theory of optimal advertisement placement in newscasts, and a justification for readers’ migration to online media platforms in order to circumvent inefficient rankings found in traditional media. We then analyze methods for restoring reader-efficient standards and discuss the political economy implications of the theory.

Keywords: Digital media; media competition; news ranking; political economy; scarcity of time.

JEL Classification: D03; L13; L82.

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1 Introduction

While there is a virtually unlimited amount of information generated and made available daily, people have neither the time nor the capacity to consume or process it all. A crucial role of the media consists of filtering this information and presenting the most relevant news to the public. This role has become increasingly important with the dramatic technological advances of the last few years.\(^1\) It is unclear how such changes have impacted the provision and consumption of news, and ultimately how informed readers are. As is widely recognized, news consumption and political knowledge play a fundamental role in the democratic process, and understanding which stories consumers select to read is critical.\(^2\)

In this paper, we model both the firms’ choices of news provision and the readers’ choices of which stories to read. Our framework provides insight into readers’ information acquisition in both traditional and new media, with a focus on online websites and news aggregators. The model can also be extended to analyze social media and other emerging platforms that are rapidly reshaping the political and media landscapes.

At the heart of our approach are two features, namely that consumers are time-constrained when processing news and that media firms essentially provide an ordering of the stories of the day. Readers have time costs associated with processing and consuming the news that are small and appear irrelevant, but they have important first-order effects. In order to maximize profits and readership, firms rank stories such that news consumers read more than they would like to, and such that they may not even read their most preferred news. This in turn has serious political and economic implications. We formally describe the kinds of stories and topics that firms use most effectively to increase news consumption and, hence, profit. In particular, we introduce a notion of “suspense potential” and characterize the conditions for which it is beneficial to firms and the conditions for which it is not. Suspense potential allows firms to delay more important stories and keep consumers reading less relevant ones, but only if these consumers do not have sufficient incentives to skip, rather than read, the lesser stories. We also analyze the effects of technological improvements, increased competition, and the effectiveness of different approaches to restore reader-optimal news rankings.

On the demand side of the market, in our framework, consumers read in a sequential manner, taking into account their time constraints. They rely on the media outlets that effectively rank stories by the ease with which the readers can access them. Readers have the choice to read or skip articles, to switch to other media outlets or to stop reading the news altogether. Whether the decisions on news consumption are made at a conscious or a subconscious level, the key aspect is that both reading and skipping articles are costly in time and cognition. These costs

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\(^1\) According to Eric Schmidt, the chairman of Google, we now generate the same amount of information in two days as we did between the dawn of civilization through 2003 (Pariser, 2011).

may vary with the media platform; for instance, skipping a story in an online newspaper is less costly than skipping one on television. Readers can also switch from one media outlet to another or return to read articles that they previously skipped.

An individual’s utility from reading an article depends on its “newsworthiness,” which is a function of its relevance and entertainment value. The utility of a story also depends on what the consumer has already read. While people may become saturated from reading a given topic and lose interest (concave utility), with others they may get caught up in the narrative and become increasingly curious as they read more (convex utility). Readers may tire more quickly of news on budgetary spending than on a colorful celebrity scandal or a politician’s transgressions. Throughout the paper, consumers are rational. They are fully aware of their preferences, and they do not misjudge their appraisal of content or underestimate their willingness to read.

On the supply side, media firms decide on a strategy for presenting the stories of the day. These outlets cannot use deceit, slant an article or make it seem more or less interesting than it actually is. They simply decide on the order in which to present the stories. We refer to their rankings, which they commit to ex-ante, as their editorial policy. In the baseline model, media firms maximize expected profits, which corresponds to maximizing readership.\(^3\) They are unbiased, and they do not draw more revenue from one subject or another. We also consider alternative objective functions for which the firms do not maximize pure readership alone.

We show that, despite their lack of bias, firms might not rank stories in the reader-optimal way. Equilibrium rankings may lead consumers to read more stories than they would like. Moreover, these stories may cover very different topics from those that readers want. This result follows from a fundamental misalignment between the consumers’ preferences over the stories they wish to read and the firms’ incentives to maximize stories read (or, for online media, “page views”). Surprisingly, these results also hold under “perfect” competition or with a zero cost of switching from one outlet to another, even when readers have no uncertainty over the rankings and newsworthiness of the stories. These findings do not rely on any kind of reader manipulation or deception, since readers are fully aware of the firms’ preferences and editorial policies. Moreover, they hold for a broad class of utilities, including saturation, linear and curiosity preferences. Intuitively, firms can induce consumers to read more by first giving them stories that they would have preferred to ignore but choose not to, because the cost of skipping them is not compensated by the utility gain from reading the most relevant stories. Even with sufficient competition, firms do not deviate from a reader-inefficient strategy, since the gain in the number of readers does not translate to a gain in readership, which also depends on the number of stories read per consumer.

In ranking stories, firms can use suspense to their advantage. Having first “hooked” the consumer, they rank important stories further down their rankings (or delay the broadcast of

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\(^3\)Online media firms that depend on advertising revenue can be seen as maximizing readership. While they may draw more revenue from some topics than from others, we maintain subject matter neutrality in the baseline case. We discuss more traditional media in the body of the paper.
these stories) to keep them on their platform longer. This “best for last” strategy is particularly effective for more entertaining, tabloid-like stories. In addition, firms coordinate in their rankings rather than defect to stories that readers would have preferred a priori. Topics that hold more suspense potential, whose definition serves to compare news both within topics and across different topics, deflect attention from stories that the readers find more newsworthy.

A central aim of this paper is the introduction of a unifying framework that can be adapted to a large range of questions related to media markets, technology and individual time constraints. We exploit the flexibility of our model to address advertisement placement and to compare diverse media settings.

The subject of advertising placement is especially relevant to the media. For instance, a rapidly growing trend among online newspapers consists of “forced-view” advertising, in which readers must view a commercial before reading a story. We incorporate this feature in our model and analyze its effectiveness for firm profits. We then consider the optimal placement of these advertisements in the ranking (referred to, in the case of online clips, as pre-roll, mid-roll or post-roll, depending on the location of the commercial), as well as the effects of changing readers’ time costs.

From a technological perspective, we find that a decrease in the cost of skipping unwanted stories is welfare-improving to readers. An increase in the ease of accessing media platforms is never detrimental. Extending our model to search engines, aggregators, and social media, we show that they can play an important role in allowing news consumers to circumvent the reader-inefficient news rankings. There is therefore tension in the effects of improved technology. On the one hand, the increased information generated causes agents to be more easily distracted and diverted from the more relevant news. On the other, technological advances aid news consumers to retrieve their preferred news more efficiently, thereby countering the diversions.

We also explore ways in which reader-efficient rankings can be restored. First, a public media outlet can play a positive role, provided that it maximizes readers' interests. Its presence leads the firms in the market to provide the reader-optimal ranking. The mechanism relies on the ease of accessibility of the public media outlet, which indirectly enforces the reader-optimal standard by pressuring firms to keep their readers from switching news sources. We also analyze conditions under which pricing can restore reader-efficient rankings, and conditions under which pricing (weakly) increases the welfare of both firms and consumers.

Lastly, we consider the political economy ramifications of our framework. The newsworthiness of a story can naturally be linked to informativeness. As readers consume these stories, they acquire information on that specific topic, and more newsworthy stories can be taken to be more informative. We place the model in a political economy environment, and explore the informational consequences of readers' time constraints. We first observe that without any bias, consumers may be uninformed on topics that they consider more important but overly informed on others. Increasing the amount of time spent on the media does not necessarily translate to
an increase in informativeness on topics preferred by readers ex-ante. When introducing ide-
ological preferences, consumers may choose outlets that share their views even when they do
not derive utility from belief confirmation (Mullainathan and Shleifer, 2005) or other forms of
bounded rationality. Rather, the outlets that share their views make it easier for readers to find
stories that interest them the most. Our model therefore provides a natural explanation for a
preference for like-minded news.

Related literature. This paper relates to several different strands of literature. It relates
naturally to the economics literature on media bias, which is surveyed in Gentzkow and Shapiro
(2008), Blasco and Sobbrio (2012) and Prat and Strömberg (2013). Our paper identifies a
new source of bias that derives from time-constrained consumers and technological aspects of
consuming news, with otherwise fully neutral and rational consumers and firms.4

The recent literature on search diversion and obfuscation in markets with an intermediary is
also relevant to our results on rankings. Ellison and Ellison (2009) provide an empirical analysis
of price elasticities and competition between internet retailers that attract customers through
a search engine; Armstrong, Vickers, and Zhou (2011) and Hagiu and Jullien (2011) show how
an intermediary platform can have incentives to divert search; Hagiu and Jullien (2013) look
at search diversion with competing platforms; Rhodes (2011) stresses the role of prominence in
otherwise frictionless markets; De Cornière and Taylor (2012) and Burguet, Caminal and Ellman
(2013) capture bias originating via advertising, and De Cornière (2011), Eliaz and Spiegler
(2011), White (2012) and Taylor (2013) study the design of search engines and analyze the
resulting quality of matches.5 This paper also relates to a rapidly expanding literature studying
the effects of technological innovations in digital media on news and advertising markets. Chiou
Jeon and Esfahani (2012), Jordan et al. (2012), Calin et al. (2013), and Dellarocas et al. (2013),
study the role of aggregators and hyperlinks as innovations in current news markets. Athey and
Gans (2010), Athey, Calvano and Gans (2012), Bergemann and Bonatti (2011), and Taylor
(2012) study innovations in the technology of advertising from a two-sided market perspective.
Levin (2013) contains a survey on innovation in internet markets.6

While our focus and framework are clearly different, these papers study phenomena that are
important for a better understanding of media markets. Our framework can also be extended

4The bounded rationality interpretation of scarcity of cognitive resources is also consistent with our model,
though we do not consider scarcity of attention in conducting more than one activity simultaneously (see, e.g.,
Simons and Chablis, 1999). For the distinct notion of rational inattention used in macroeconomics and finance,
see Sims (2003, 2006), as well as Reis (2006) and Mackowiak and Wiederholt (2009), among others.
5For studies of communication and information overload that consider agents sending information and com-
peting to reach audiences, see van Zandt (2004) and Anderson and de Palma (2012). We avoid this issue by
assuming that firms all have access to the same set of stories.
6Within the broader media and communications literature, Hindman (2009) and Boczkowski (2010) study the
consumption and production of (political) news in digital media (see also Hamilton, 2004, Ch. 7); Pariser (2011)
discusses the dangers of a filtered and individually targeted internet; Curran, Fenton and Freedman (2012) argue
that the internet has not fulfilled many expectations raised; Lovink (2012) discusses media and social networks.
to these domains of analysis and can be instrumental in obtaining new insights. At the same
time, our framework addresses the two-sided nature of news media markets in a reduced form
way that allows for a more tractable analysis.

This paper is structured as follows. Section 2 introduces the baseline framework, Section 3
shows the main features and presents illustrative examples, Section 4 extends the models, and
Section 5 concludes. All proofs are in the Appendix.

2 Model

We consider an environment in which a state of the world, when realized, is described by a list
of stories that are exogenous and commonly available to all media outlets. Readers derive utility
from the stories they read. Locating news stories is costly, and consequently their presentation
by the media outlets is relevant. Our model makes explicit the outlets’ choice of editorial policies
for ranking stories. We now describe the details of our baseline framework.

2.1 News Sources and True State of the World

The true state of the world is described by a set S of stories. We assume for simplicity
that there are two categories of stories corresponding to two topics covered, A and B. Setting
K = {A, B}, we denote by Sk ⊂ S stories that correspond to total stories on topic k, for k ∈ K,
so that S = ∪k∈KSk. We implicitly assume that the news sources provide these stories to all
media outlets. These sources could be governments, corporations, or news agencies such as
Reuters or Associated Press. Topics could represent broad categories, such as international and
domestic news, politics or entertainment, or they could be more specific categories, such as news
in the Middle East. We also assume that S has cardinality N.

The elements of S are written as skn = (λkn, zkn) and are characterized by newsworthiness
λkn ∈ [0, λ], for some λ ∈ R+, and an identification variable zkn ∈ N × K that indicates a topic
k ∈ K and a number n ∈ N to distinguish between stories with the same newsworthiness and
topic. Newsworthiness λkn measures how important and informative a story is to readers. We
allow for completely irrelevant stories, with newsworthiness λ = 0, to exist. We use the notation
λ(sk) to denote the newsworthiness of story sk (i.e., λ(sk) = λkn). In the basic version of the
model, the variable zkn simply identifies stories within the set Sk. In Section 4.4, it will
also contain a measure of the content of a story.

Since, on a given day, the true state of the world is a realization of the set of stories S, we
can identify the space of possible states of the world with ordered tuples of realizations of
newsworthiness and topic S ⊂ Ω = ([0, λ] × N × K)T, λ ∈ R+. We always assume the number
of possible stories N, states T, and hence S, to be finite. There is a prior over the states of the
world (formally, π ∈ Δ(S)), which we assume to be common knowledge.
2.2 Media Outlets

There are two firms, denoted \( i \in I \), where \( I = \{1, 2\} \), and their strategies consist of ordering the stories for each state of the world. Specifically, given a realization of stories \( S \in \mathcal{S} \), the strategy \( \sigma^i \in \mathcal{P}_N \) of media outlet \( i \) is a total strict ranking of the stories in \( S \); set \( \sigma = (\sigma^i, \sigma^{-i}) \) and let \( \mathcal{P}_N \) denote the set of permutations of \( S \), which are fully and strictly ordered \( N \)-tuples of stories in \( S \). An outlet here cannot carry out its own investigation and cannot magnify or trivialize the newsworthiness of stories; it only has the technology to rank given stories in the order in which readers view their headlines. The notion of not reporting a story effectively corresponds to leaving a story to the end of the ranking.

In the overall game that we consider, outlet \( i \)'s strategy is a map \( \sigma^i : \mathcal{S} \rightarrow \mathcal{P}_N \). Since the true state of the world is unknown to the readers, this game is formally a Bayesian game of incomplete information.

In any state of the world and given the set of stories \( S \), media outlet \( i \) chooses \( \sigma^i \) to maximize expected profits, which, with a unit price per story read and zero fees collected from viewers, reduces to:

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\Pi^i(\sigma^i|\sigma^{-i}) = \sum_{k \in K} \sum_{n \in S^i_k} \mu^k_{n,i}(\sigma^i, \sigma^{-i}),
\]

where \( \mu^k_{n,i} : (\mathcal{P}_N)^I \rightarrow [0, 1] \) is the mass of readers that firm \( i \) expects will read story \( s^i_n \) from it. In our basic model, a firm’s profits are a function of the readership it obtains on all its stories.

We view a media outlet as having an editorial board that decides on a strategy (ex-ante) for displaying the news, for any given realization of state of the world. This strategy is public and commonly known. That is, each firm knows the other firm’s strategy, as do the readers. In particular, the media outlets also know the state \( S \) as soon as it is realized, while the readers do not. The reasoning behind the common awareness assumption is that a newspaper’s editorial stance and presentation style is generally known to a large degree. Furthermore, while we focus on a single period, our model can be viewed as the reduced form of the repeated interaction that exists in reality, and that reinforces the common awareness of each outlet’s editorial policy. Relaxing this assumption may accentuate the results obtained below.

2.3 Readers

There is a continuum of readers who all have the same preference except that they can differ in terms of which website or newspaper they open first.\(^8\) We assume that a reader can only see one headline at a time and that observing a headline discloses the story’s topic and newsworthiness. However, a reader does not derive utility from a headline unless he reads the story. When

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\(^7\)We consider in Section 4 more general profit functions that include factors such as viewer fees and revenues deriving from airing time-consuming advertisements.

\(^8\)Given the focus of our discussion, the homogeneity of preferences assumption simplifies the exposition and allows us to elucidate certain benchmark scenarios. We briefly discuss heterogeneity in Section 3.4.
deciding whether or not to read a story, a reader takes into account the history of all stories he has read and all the headlines he has seen. He also takes into account his expectations over future headlines and stories, which is a function of his history and of the strategy chosen by the editorial board of each newspaper. Besides reading, the consumer has the option of skipping a story and looking at the next headline; alternatively, he can return to reading a story that he previously skipped. He can also switch from the website or newspaper he is currently browsing to the other. Lastly, he has the option to stop reading the news altogether. Reading, skipping stories, or opening a new website for the first time each have an associated (time) cost.

Formally, the continuum of readers is normalized to mass 1. Let $M_1$ and $M_2 = 1 - M_1 \in [0, 1]$ denote the mass of readers that first access outlets 1 and 2, respectively. We use the term “bookmark” to denote the first outlet accessed by a reader, which, for the moment, is exogenously given.\footnote{The bookmark partly covers other factors of reader preference, such as preference for a reading style, ease of access or being accustomed to a newspaper’s layout. We consider below the important case in which readers can switch to other outlets at zero cost. Effectively, this also covers the case in which the bookmarks are endogenous.} Periods at which readers make their choices are denoted $t \in \{1, \ldots, T\}$, but these periods need not correspond to a notion of time. Rather, they keep track of the sequence of the agent’s choices. A period refers to the stage at which the reader takes an action $a_t \in \{RD, SK, SW, ST\}$ to read a story ($RD$), to skip it ($SK$), to switch to a not previously accessed outlet ($SW$) or to stop reading altogether ($ST$). Readers derive utility from reading articles and incur a time cost from any of the actions $RD$, $SK$ and $SW$. $ST$ terminates the reader’s game. We normalize the agent’s continuation utility of stopping to 0.

When choosing $a_t$, readers know the strategies of the media outlets $\sigma$, but they do not observe the realization of the state of the world $S$. While the readers are familiar with the outlets’ editorial policy, they do not necessarily have sufficient information to infer the realized state of the world ex-ante. However, their histories, their observations and their knowledge of the outlets’ strategies $\sigma$ allow them to update their beliefs. In particular, the firm’s choice of ordering has taken place before the reader’s decision so that the firms do not respond to each reader’s choice by reordering the stories.\footnote{As the media’s online technology improves, their ability to re-order the stories to fit a specific reader becomes increasingly more relevant. This type of technology does not feature in the present model, but it would not impact the results. We return to this point in Section 3.4.}

At any period $t$, the reader has history $H_{t-1}$ of all the stories he has previously read or seen the headlines to. For any action $a_t \in \{RD, SK, SW, ST\}$ taken in period $t$, given that the reader is observing headline $s^k_n$, the pair $\{s^k_n, a_t\}$ is appended to his history so that $H_t = \{\{s^k_n, a_t\}, H_{t-1}\}$. Set $H_0 = \emptyset$ for the reader’s history at period 1. Implicitly, the history $H_t$ given by $H_{t-1}$ and the currently chosen action, together with the following, determine the position of the reader’s cursor after period $t$:

**RD** When a reader chooses to read a story, he observes the next story of the outlet’s ranking:

$$\text{given strategy } \sigma^i = (\sigma^i_1, \ldots, \sigma^i_N), \text{ if at time } t \text{ he reads story } \sigma^i_n, \text{ then the next observed story is } \sigma^i_{n+1}, \text{ where } \sigma^i_n = \emptyset \text{ for } n > N, \ i \in I;$$
**SK** when a reader skips to another story, he observes $\sigma_{n+1}^i$; if he skips to an outlet he previously opened, then given his history $H_{t-1}$, he observes the last unread story in his history; if he skips to a story that he previously skipped, in either outlet, then his next observation remains $\sigma_{n+1}^i$.

**SW** when a reader switches from outlet $i$ to a thus far unopened outlet $-i$, he observes the first headline of outlet $-i$, $\sigma_1^{-i}$.

Actions $RD$, $SW$, and $ST$ are then always well-defined. Since $RD$ refers to reading the current article identified by the cursor, $SW$ always refers to switching to the first story of the so far unopened other outlet, and $ST$ always terminates the reader’s game. The action $SK$, however, needs further specification. We assume that the reader can choose to skip forward to the next not yet accessed story of the outlet he is currently reading, or he can skip backward to any previously accessed but not read story in $H_{t-1}$.

The physical length of time of any period $t$ depends on the action $a_t$ chosen by the reader in that period. The variable that keeps track of physical time is $\tau_t \in \mathbb{R}$, which measures the time spent reading, skipping and switching by the end of period $t$. Set $\tau_0 = 0$ and define $\tau_t = \tau_{t-1} + \nu_{a_t}$, where time spent as a function of the action taken satisfies $0 \leq \nu_{SK} \leq \nu_{RD}$ and $0 \leq \nu_{SW}$. In words, it is never more costly to skip a story than to read it, and costs are never negative. We also keep track of the aggregate amount of news consumed on topic $k \in K$ by the end of period $t$. Specifically, we keep track of the total amount of news consumed $x_t^k$ on this topic, in all periods up to and including period $t$. This total amount is expressed as

$$x_t^k = \begin{cases} x_{t-1}^k + \lambda(s_t^k) & \text{if } a_t = RD \\ x_{t-1}^k & \text{otherwise}, \end{cases}$$

where $x_0^k = 0$.

We are now in position to define the reader’s maximization problem. At any period $t \in \{1, \ldots, T\}$, given observed headline $s_n^k$ and history $H_{t-1}$, the agent chooses action $a_t \in \{RD, SK, SW, ST\}$ that maximizes the expected utility function

$$U_t(a_t|s_n^k, H_{t-1}, \sigma) = \sum_{k \in K} \Delta u_k(x_t^k, x_{t-1}^k) - \Delta c(\tau_t, \tau_{t-1}) + EU_{t+1}(a_{t+1}|H_t, \sigma),$$

where $\Delta u_k(x_t^k, x_{t-1}^k) = u_k(x_t^k) - u_k(x_{t-1}^k)$ and $\Delta c(\tau_t, \tau_{t-1}) = c(\tau_t) - c(\tau_{t-1})$. As discussed in the next subsection, the reader effectively considers the added instantaneous benefit, $\Delta u_k(x_t^k, x_{t-1}^k)$, minus the instantaneous cost, $\Delta c(\tau_t, \tau_{t-1})$, plus the future expected utility.

We assume that the instantaneous utility function, $u_k(\cdot)$, is increasing, $(u'_k(\cdot) > 0)$, for $k \in \{A, B\}$. If $u''_k(\cdot) = 0$, then the agent’s preference for stories on topic $k$ is independent of what he has previously read. If $u''_k(\cdot) > 0$, then they are complementary; having already read stories on topic $k$ increases the marginal utility of additional stories. We also refer to the topic
with complementary stories as one for which readers have curiosity preferences: their interest in the subject grows as they read about it. If \( u'_k(\cdot) < 0 \), then the agent has diminishing marginal utility of reading additional stories on a topic. We assume that \( u'_A(\cdot) = 0 \) and focus more on the curiosity case for topic \( B \), but our main results would hold with other preferences as well, including linear topic \( B \) preferences.

If the agent chooses to stop at any point (\( a_t = ST \)), then he cannot return to reading in the future, and his expected utility from that period onwards is \( EU_{t+1}(s^k_{t'}, a_{t'}|H_{t-1}, \sigma) = 0 \). We assume that \( c'(0) > 0 \) and \( c''(0) > 0 \). Having the cost of reading be convex in the time spent serves the purpose of having the consumer stop reading altogether, after a certain stage. In the limit where the cost is infinitely convex, the agent essentially has an exact amount of time for news that he is not willing to exceed. For instance, he reads news for no more than 30 minutes in the morning, regardless of what news is available. In the other limit where the cost is linear, the agent’s cost of time is always the same, whether it is the first minute or the 29th.

Finally, note that if the reader were to always prefer reading every story, then this model would be vacuous in that scarcity of time would not be a binding constraint. To guarantee that readers will not choose to read all stories in \( S \), we usually assume the following: \( c(0) = u_k(0) = 0 \) and \( c'(0) < u'_k(0) \) for \( k \in K \), and \( c(N_{RD}) > \sum_{k \in K} u_k(\sum_{s \in S} \lambda(s^k)) \), for any \( S \in \mathcal{S} \). In other words, the cost of reading articles increases faster than the extra utility derived, and the total sum of utility obtained from reading all articles is less than the total cost of having read them; in particular, this implicitly assumes that \( \nu_{RD} > 0 \).

### 2.4 Properties of Readers’ Preferences

Before describing the timing of the game, we explain the intuition of the reader’s preferences. There are different, but equivalent, interpretations that apply to the utility function described above. The first is the notion that the agent sequentially performs, in any “period” \( t \), a marginal benefit-marginal cost analysis. Before deciding whether to read a story on topic \( k \), he considers the additional instantaneous utility he would receive from \( \Delta u_k(x^k_t, x^k_{t-1}) \), added to his expected future utility, \( U_{t+1}(a_{t+1}|H_{t}, \sigma) \). He weighs this marginal benefit against the marginal cost of the additional time it would take to read this story, \( \Delta u_k(x^k_t, x^k_{t-1}) \). The second interpretation is that the reader is maximizing, in a standard way, his ex-ante utility function for every possible terminal history. This second approach is not always thought of as being sequential, but the two methods lead to identical behavior.

To show that the two interpretations are behaviorally equivalent, we first note that the agent is dynamically consistent: if, ex-ante, he intends to take a specific action at a future given history, then he does not change his mind if he reaches that node.

**Lemma 1 (Dynamic consistency).** Suppose that at time \( t \), the agent’s period \( t \) utility maximization choice consists of taking action \( a_t \) at future history \( H_{t'} \), where \( t' \geq t \). Then, at time \( t' \) and history \( H_{t'} \), the agent period \( t' \) maximization choice also consists of taking action \( a_{t'} \).
In other words, the agent is not in a conflict with his future self. Even in the case in which the agent’s choice to read an article on a given topic $k$ increases his marginal utility of reading more stories on this topic ($u'_k > 0$), he is fully aware of this beforehand. He does not become “addicted” in a way that he had not anticipated. Since the agent is temporally consistent, it suffices to consider his expected utility in the ex-ante stage, as he will not deviate from his plan of action. Therefore, as a second interpretation, we can also think of the agent as simply maximizing his ex-ante expected utility.

Lemma 2 (Ex-ante utility maximization). Let the agent’s ex-ante plan of action be denoted by $P_0$, and let $p_0(H_T|P_0, \sigma)$ denote the agent’s ex-ante probability of reaching terminal history $H_T$. The agent takes the plan of action that maximizes expected utility $U_0(P_0|\sigma) = \sum_{k \in K} p_0(H_T|P_0, \sigma)[u_k(x^k_T) - c(\tau_T)]$.

That is, the agent simply takes the ex-ante plan of action that will maximize his expected utility of total (ex-post) news read, $x^k_T$, on each topic $k \in K$, minus the total (ex-post) cost incurred, $c(\tau_T)$. Note that under the first interpretation, considering the ex-interim stage, the agent’s utility is not time-separable when $u_k$ is not linear. In particular, if $u'_k > 0$, then the more the agent reads of a story, the more utility he derives from it. Under the second (ex-ante) interpretation, however, the agent essentially has a static choice, in which he maximizes standard expected utility function over all possible final outcomes.

2.5 Timing and Equilibrium

The timing of the game is as follows:

Stage 0 Media outlets simultaneously choose the rankings $(\sigma^i(S))_{i \in I}$ for every possible state of the world $S \in S$. These rankings are observed by all parties.

Stage 1 Nature draws the state of the world $S \in S$, which is disclosed to the media firms but not to the readers.

Stage 2 There are several subperiods $t \in \{1, \ldots, T\}$. In subperiod $t = 1$, readers in mass $M_1$ observe the first headline of firm 1, and readers in mass $M_2 = 1 - M_1$ observe the first headline of firm 2. In subsequent subperiods $t \geq 2$, readers update their beliefs about the state of the world and choose an action $a_t$ for every subperiod, consume the corresponding news items, and incur the corresponding costs.

Stage 3 Final payoffs of firms and consumers are realized.

This leads to an extensive-form game of incomplete and imperfect information $\Gamma_{ext}$ between media outlets and readers. Given media outlets’ strategies in stage 0 and given that consumers
are individually negligible and independent of each other, consumers’ expected demand is always well-specified and straightforward to derive.

**Lemma 3 (Reader demand).** Let \( \sigma = (\sigma^i)_{i \in I} \) be a strategy profile of firm rankings in stage 0; then there exists a function \( \mu^{k,i}_n \) that associates to each such profile the expected mass of readers going to an outlet \( i \) on given story \( s^k_n \) of any given topic \( k \), \( n \in \mathbb{N}, k \in K \).

This allows us to reduce the overall extensive-form game \( \Gamma_{ext} \) to a simultaneous game of complete information \( \Gamma \) between just the media outlets.\textsuperscript{11}

**Proposition 1 (Existence).** The game \( \Gamma \) always has a Nash equilibrium.

Generally speaking, existence of a Nash equilibrium is guaranteed in mixed strategies. Although not always necessary, we assume throughout that a pure strategy equilibrium exists.\textsuperscript{12} When confronted with multiple equilibria, we select those that generate the largest profits to the media outlets, unless stated otherwise.

### 3 Technology, Rankings and News Acquisition

In this section, we present the key implications of the baseline framework. We first establish benchmark results on reader-efficiency and coordination of rankings across outlets. Then we show both formally and by means of a simple example how significant inefficiencies can occur due to consumers’ time constraints. Technology, as captured by the strategic possibilities of the media firms and by various costs that consumers face when using the media, plays a key role in our analysis.

#### 3.1 Reader-Efficient Features and Coordination Benchmark

The intuition that lower costs of skipping stories and switching outlets are generally beneficial for consumers and not for firms is largely correct. However, there are important caveats. Skipping costs bound the maximal welfare loss for readers when the number of stories available to firms is fixed. As more information is generated, the maximal welfare loss to readers may increase, if the skipping cost is fixed. When skipping costs are zero, reader efficiency – that is, the utility-maximizing ranking – is always achieved. However, an increase in the intensity of competition, even in the limit of zero switching costs, yields only existence and not uniqueness of a reader-efficient ranking. In fact, the more natural equilibrium refinement is typically not

\textsuperscript{11}Throughout the paper, we assume that whenever he is indifferent between two plans (or continuation plans) of action, the consumer always chooses the plan that maximizes the number of stories read on the bookmarked outlet. If there are more than one such plans, then he chooses among them the one that further maximizes the number of stories read on the other outlet. If there are still more than one, then he further randomizes (uniformly) among these remaining plans. This assumption makes the selection \( \mu^{k,i}_n \), and hence the game \( \Gamma \), well-defined.

\textsuperscript{12}See Reny (1999) for a set of sufficient conditions for the existence of pure strategy equilibria and symmetric pure strategy equilibria.
reader-efficient. We also show that under homogeneity conditions, firms coordinate on their rankings, and consumers need not skip or switch outlets.

Skipping costs bound the utility loss of the readers. If there are \( N \) stories, then the loss in welfare to a reader, compared to his most-preferred reading list, is of no more than \( 2N\nu_{SK} \). This result is general since, at worse, the reader can skip all \( N \) stories and then read the ones he prefers.

**Proposition 2 (Skipping cost and reader welfare).** For any given game \( \Gamma \) and Nash equilibrium \( \sigma \) of \( \Gamma \), the expected welfare loss to any reader from \( \sigma \) relative to the reader-efficient strategy \( \sigma^* \) is bounded above by \( 2N \cdot \nu_{SK} \), for any \( \nu_{SK} \in \mathbb{R} \).

We make the following observations. Reducing the skipping costs always results in a welfare improvement for readers in terms of bounding the welfare losses. However, if \( N \), the number of stories generated, were to increase, then the maximum welfare loss would increase. Proposition 2, while immediate, foreshadows the positive and negative aspects of technological advances, which we return to later. We also emphasize that a small bound in utility loss does not in itself mean that the consumer reads articles close to his preferred bundle; in fact, they may be very different even if the bound is small. We discuss this point in the political economy application. Maintaining the maximum number of stories fixed yields our first efficiency benchmark.

**Corollary 1 (Skipping cost and reader efficiency).** For any given game \( \Gamma \), there exists a \( \bar{\nu}_{SK} > 0 \) such that for any \( \nu_{SK} < \bar{\nu}_{SK} \) there exists a reader-efficient Nash equilibrium of \( \Gamma \). Moreover, if \( \nu_{SK} = 0 \), then all Nash equilibria are payoff-equivalent to the reader-efficient ranking.

The extent to which skipping costs are currently decreasing with technological advances is ambiguous. It is unclear whether online newspapers have lower skipping costs than traditional print, especially with the current trend of online videos and varying screen sizes. Podcasts, however, have lower skipping costs relative to the radio broadcast of the same programs. Similarly, digital video (DVR) recording devices such as TiVo allow viewers to reduce the television cost of skipping. We elaborate on comparing different skipping costs and media types in Section 4.3, but note that to the extent that they can, media firms have incentives not to make skipping costs too low.\(^{13}\)

If we do not hold the number of stories fixed, then the reader-efficient benchmark does not hold for positive skipping costs. In the limit of \( \nu_{SK} = 0 \), agents always get the reader-efficient ranking since they can effectively skip all the stories at no cost, learn the state of the world, and then read the utility maximizing stories. For low enough switching costs, the following result guarantees the existence of a reader-efficient equilibrium at zero switching costs.

\(^{13}\)In practice, with heterogeneous readers, firms would also not want to make skipping costs too high; we return to this point in Section 3.4.
Proposition 3 (Switching cost and reader efficiency). For any given game $\Gamma$, there exists $\bar{\nu}_{SW} > 0$ such that, for any $\nu_{SW} < \bar{\nu}_{SW}$, there exists a reader-efficient Nash equilibrium of $\Gamma$.

While a reader-efficient equilibrium exists for low switching costs, it is generally not the case that the natural Nash equilibria are reader-efficient, including in the limit where $\nu_{SW} = 0$. This is illustrated in the example in Section 3.2 below. Nonetheless, under certain conditions, lower switching costs are at least not detrimental to readers; whereas lower skipping and/or switching costs may be detrimental to firms.

Proposition 4 (Switching/skipping cost and welfare). For any given game $\Gamma$, assuming that there are no switches in equilibrium, firms’ expected profits at the profit-maximizing Nash equilibria are weakly increasing in the switching cost $\nu_{SW}$, and readers’ expected utilities are weakly decreasing. The same holds for the skipping cost $\nu_{SK}$.

In other words, increased intensity of competition, represented by a lower switching cost $\nu_{SW}$, makes readers (weakly) better off and firms (weakly) worse off, reaching monopoly profits for the firms when $\nu_{SW}$ is sufficiently large, but without necessarily reaching the reader-efficient level when $\nu_{SW} = 0$. This result implies that media firms benefit when they have mechanisms for raising their readers’ switching costs, as their profits would increase. The same applies for the skipping cost $\nu_{SK}$, with the difference that a zero skipping cost does lead to reader efficiency, as discussed above.\[^{15}\]

The following result shows that switching does not occur in equilibrium when readers are homogeneous and when there is no uncertainty. Moreover, firms coordinate on their rankings when the selected equilibria are those that favor the firms.

Proposition 5 (Coordination benchmark). For any given game $\Gamma$ with one state of the world, and at any pure Nash equilibrium $\sigma$ of $\Gamma$, both firms have the same profits per reader, and no switches occur. Moreover, for any such Nash equilibrium $\sigma$ of $\Gamma$, there always exists a pure Nash equilibrium $\sigma'$ with $\sigma'_1 = \sigma'_2$ that also involves no skips and is weakly Pareto-improving for all market participants.

This result holds for any level of switching or skipping costs and, thus, provides a first rationale for why news segments across outlets may be similar in practice. Clearly, with heterogeneous readers, differentiation may obtain, as we discuss in Section 3.4.

### 3.2 Reader-Inefficient Features

Turning to reader-inefficient features of equilibrium rankings, we show that readers may read too many stories and on the wrong topics, even when there is no uncertainty over the state of

\[^{14}\]See Proposition 5 for sufficient conditions ensuring no switching.

\[^{15}\]Note that with heterogeneous readers, firms may prefer not to have too high a skipping cost, as they may lose consumers who would read some stories that are not ranked sufficiently prominently for them. We return to this point in Section 3.3.
the world. This also holds in the “perfect” competition case of a zero cost of switching between outlets. We develop a simple example to illustrate this and other results, and defer a more formal analysis to the subsequent section.

**Example setup.** Throughout the examples in the paper, we assume the following setting. There are two media firms, \( i \in I = \{1, 2\} \), reporting on two topics, \( k \in K = \{A, B\} \). Readers are homogeneous and all have utility functions \( u_A(x) = x \) over topic \( A \) and \( u_B(x) = 2x^2 \) over topic \( B \), and their time cost function is given by \( c(\tau) = d\tau^3 \), where \( d > 0 \) is a parameter.

Readers have linear preferences for topic \( A \), as may be the case with “economic news” or “international news,” while they have convex (curiosity) preferences for topic \( B \), as may be the case with “celebrity gossip” or “political scandals”: as the consumer reads about the topic, his curiosity grows and he wants to read even more. Since the definition of a topic is general, these preferences are also compatible with the broad idea that the more entertainment a reader receives, the harder he finds it to stop. While we could allow for another topic in which readers have concave (saturation) preferences, or even with changing curvature signs on a topic, we focus on the linear and convex (curiosity) cases for simplicity. The result of excessive reading does not depend on having curiosity preferences on any topic. We make this assumption for illustrative purposes only. Recall that in the benchmark case, firms maximize readership (in order to maximize profits) and are otherwise unbiased; readers’ utilities only depend on newsworthiness.

Assume a time cost parameter \( d = 4 \) and a reading cost of \( \nu_{RD} = 0.3 \). There is a single state of the world,

\[
S = \{(1, z_1^A), (0.5, z_2^A), (0.456, z_1^B), (0.455, z_2^B), (0.454, z_3^B)\},
\]

with five stories, of which two are on topic \( A \) with levels of newsworthiness 1 and 0.5, and three are on topic \( B \) with levels of newsworthiness 0.456, 0.455, and 0.454.\(^{16}\) Then, as there is only one state of the world, the reader knows exactly what the ranking is and faces no uncertainty.\(^{17}\) In this example, there are far fewer stories than in practice, and readers’ time constraints are strong. But it serves to highlight the mechanism behind our results, which also hold for more stories, more topics and more time available.

The reader-efficient ranking consists of any ranking that places story \((1, z_1^A)\) on topic \( A \) first. For instance, as is consistent with Corollary 1 and Proposition 4, the ranking

\[
\sigma^* = \{(1, z_1^A), (0.5, z_2^A), (0.456, z_1^B), (0.455, z_2^B), (0.454, z_3^B)\}
\]

\(^{16}\)The levels of newsworthiness are not directly comparable across topics, since the agent’s utility may differ from one topic to another.

\(^{17}\)The agent is aware of the story’s newsworthiness, but this does not mean that he is aware of its content. The specified state of the world is a collection of all the states that have the same newsworthiness but may differ in content. Since the reader has no preferences over content, we do not specify these states for simplicity. We separate states with different content but identical newsworthiness in the political economy discussion in Section 4.4, which explicitly links content to information.
constitutes a Nash equilibrium for a sufficiently small skipping cost. In this case, readers only read story \((1, z_A^1)\) and then stop. We omit the details of the calculation, but note that, by Lemma 2, it suffices to consider the ex-ante utility maximization problem. Here, by reading only story \((1, z_A^1)\), the agent obtains total utility \(u_A(1) - c(\nu_{RD} = 0.3) = 1 - 4(0.3)^3 = 0.892\). His utility would diminish if he were to read more, or any other set of stories.\(^{18}\)

**Monopoly: too many stories and on the wrong topic.** Consider the case of monopoly outlets, which corresponds to a switching cost \(\nu_{SW}\) that is sufficiently large that readers never switch. Assume also that the skipping cost is \(\nu_{SK} = 0.05\). The reader-efficient ranking \(\sigma^*\) is no longer an equilibrium at this higher skipping cost. Instead, firms rank the stories in the following order,\(^{19}\)

\[
\hat{\sigma} = \{(0.454, z_B^3), (0.455, z_B^2), (0.456, z_B^1), (0.5, z_A^4), (1, z_A^4)\}.
\]

The reader will choose not to skip any stories and read the first three stories in the ranking \(((0.454, z_B^3), (0.455, z_B^2), (0.456, z_B^1))\), and then stop, obtaining utility \(u_B(0.454 + 0.455 + 0.456) - c(0.9) \approx 0.810\). In particular, he will not read his preferred story \((1, z_A^4)\). It is straightforward to show that he cannot improve on this utility by making any other choices. The reader-efficient outcome, therefore, does not occur in equilibrium.

Thus, this example contains these two central features: the consumer reads **too many stories** – he reads three stories instead of one; and he reads the **wrong stories** – all the stories he reads are drawn from the “less preferred” topic \(B\) instead of from \(A\). These results hold with full dynamic consistency, without any manipulation on the part of the media, with no external bias, and without uncertainty. They also do not rely on curiosity preferences.

Note that, after having read the first two stories from topic \(B\), the consumer strictly prefers reading the third story from topic \(B\), \((0.456, z_B^1)\), over his originally preferred story, \((1, z_A^4)\) from topic \(A\). If given the choice, he would not substitute story \((1, z_A^4)\) for \((0.456, z_B^1)\). This feature, unlike the excessive reading and wrong story results, does depend on the reader’s curiosity preferences for topic \(B\). There is a **path dependence** in his preferences, and the more he discovers about it, the less he is willing to learn about other matters instead. For instance, a consumer who may originally have been interested in political news now prefers reading about a celebrity scandal.

\(^{18}\)For instance, note that if the agent were to read both stories from topic \(A\), he would obtain utility \(u_A(1.5) - c(2 \times 0.3) = 1.5 - 4(0.6)^3 = 0.636\). Equivalently, by expected utility representation in 1, reading only the additional story \((0.5, z_A^2)\) from topic \(A\), would provide additional expected utility \(\Delta u_A(1.5, 1) - \Delta c(2 \times 0.3, 0.3) = (u_A(1.5) - u_A(1)) - (c(0.6) - c(0.3)) = 0.5 - 0.756 < 0\), which also reveals that he would not read the story. Simple algorithms can be applied to obtain reader-efficient ranking as well as firms’ optimal rankings, which are made considerably easier to compute by Proposition 6. We do not discuss these methods in the interest of space.

\(^{19}\)The ranking is not unique, but the stories read will be the same for all equilibria. We follow the convention of always ordering the stories (that are read) from least to most important, whenever possible.
Perfect competition: persistence of inefficiencies. These inefficiencies persist when competition intensifies and are present even in the limit of “perfect competition”, or, more precisely, when the switching cost is zero, $\nu_{SW} = 0$. Suppose that both firms have the same measure of bookmarked consumers, $M_1 = M_2 = 1/2$. Then, both firms choosing the monopoly strategy, $\sigma_1 = \sigma_2 = \hat{\sigma}$, constitutes a Nash equilibrium. A firm can only profitably deviate by capturing the other firm’s market share, and since there is no collection of two stories that the reader would prefer to the three of topic $B$, this requires having the consumer read exactly one article, story $(1, z_1^A)$. Firm 1 will not deviate from strategy $\sigma_1 = \hat{\sigma}$ when $M_1 > 1/3$. Similarly, firm 2 will not deviate from strategy $\sigma_2 = \hat{\sigma}$ when $M_2 > 1/3$ (or equivalently, $M_1 < 2/3$). Since $M_1 = M_2 = 1/2 \in (1/3, 2/3)$, neither firm deviates from $\hat{\sigma}$.

The result does not hinge on there being two firms, or on the assumed range $(1/3, 2/3)$ of the measure of readers. A similar equilibrium can easily be sustained with more firms, or for a larger range, with the inclusion of more stories. By Proposition 3, a reader-efficient equilibrium also exists, but the equilibrium above yields firms the highest payoffs and is therefore the one chosen by our selection criterion.

Hence, even with competing outlets, consumers may read too many stories, and these may not be the ones they would like to read. But while more intense competition may not reduce these inefficiencies, a large enough reduction in skipping cost does yield the reader-efficient ranking by Proposition 2.

Curiosity, story endowment, and tabloid news. Demand for news on a given day often depends on the stories consumed on previous days. We take this into account by keeping track of the “endowment” of stories read. More concretely, so far we have assumed that $H_0 = \emptyset$, meaning that consumers’ history did not include any story read prior to $t = 1$, and thus $x_0 = 0$. But we can allow for $H_0 \neq \emptyset$ and $x_0 > 0$.

Suppose, then, that agents are endowed with a story, at no additional time cost. For instance, an individual who follows the presidential elections is essentially endowed with past stories on the topic. If these stories are in topic $A$, then the story endowment has no relevance. If the endowment is in topic $B$, inducing curiosity, then it can impact readers’ choices.

In our running example, it is straightforward to see that a large enough story endowment in topic $B$ – for instance, an endowment of $(1, z^B)$ – implies that the reader’s preferences would change to preferring the three stories from topic $B$ to any from topic $A$. In a political economy setting, it may be in the interest of a candidate to use an unrelated event, or to provide a relatively entertaining, but politically irrelevant, minor “gaffe” to shift the reader’s attention away from a deeper, politically more problematic story about his actual policies. Media firms also have a preference for such occurrences to the extent that these increase the readers’ inclination to read or watch more stories. This result highlights a further element of the style typically associated with entertaining and sensationalist stories covered by “tabloid” news outlets (e.g., The Sun and The Daily Mirror in the UK), for which the aspects of curiosity and “follow-up”
preferences are particularly pertinent.

### 3.3 Ranking and Suspense

Firms follow general rules in the way they present stories to readers. Some features of stories and topics hold special appeal to firms but not necessarily to consumers. For simplicity, we focus on the case of no uncertainty over newsworthiness and prohibitively high switching costs (monopoly outlets). Then, firms rank the stories that consumers will read from least to most important. That is, they order them in increasing order of relevance, and they leave “the best for last” to lure the consumers into reading more. In particular, the following “reverse-order” result holds for stories read.

**Proposition 6 (Best for last).** Let \( \Gamma \) be a game with one state of the world and large switching cost \( \nu_{SW} > \bar{\nu}_{SW} \), for some \( \bar{\nu}_{SW} > 0 \), and suppose that \( u^k(\cdot) \geq 0 \), for \( k \in K \). Then:

(a) For any Nash equilibrium \( \sigma \) of \( \Gamma \), there exists a payoff-equivalent Nash equilibrium where, for any given topic, stories read within that topic are ranked by increasing order of newsworthiness, with the first story read being the least important story read, and so on.

(b) The converse does not hold; that is, for a Nash equilibrium \( \sigma \) of \( \Gamma \), where stories read are ranked by increasing order of newsworthiness, there need not exist a payoff-equivalent Nash equilibrium where stories read are ranked by decreasing order of newsworthiness.

An instance of this result can be found in the equilibrium ranking \( \hat{\sigma} \) of the example in Section 3.2. It is also common for radio or television news stations to leave the main story to the end of a news segment after having announced it at the beginning. In addition, events such as the Academy Awards announce the winners of the most important categories at the end, and cinemas show the main feature after having shown trailers and advertisements. Similarly, in online media, individual stories in audio or visual format are often preceded by advertisements and other less relevant stories.\(^{20}\)

While this “reverse-order” strategy is used extensively in practice, it is not used universally. Specifically, reverse ranking may be used to a lesser extent when there is significant heterogeneity of preferences, when an unexpectedly important story occurs, or when readers have a strict preference for reading the more important news of the day first. In these cases, firms may sometimes rank more important stories first, especially when skipping costs are sufficiently low, and use reverse-ranking over a subset of stories only. The reverse-ranking result is stronger with media such as television or radio, for which skipping costs are high. We return to this when comparing equilibria across media types in Section 4.3.

\(^{20}\)Proposition 6 simplifies considerably the maximization problem of the firms, as it effectively reduces the size of the state space to consider. In the interest of space, we omit the details of the method used to determine the optimal rankings.
Another implication of the last proposition concerns the ranking across topics. Stories of a given topic need not necessarily be grouped together in the ranking, and it may sometimes be optimal to “unbundle” stories. That is, different topics may appear one after the other, with readers possibly switching between topics while reading successive stories. This is not unusual in news, particularly online news. In practice, the effect may be dampened by possible consumer preference to read stories within topics together.

**News with suspense.** In addition to the reverse-ranking result, there is a well-defined type of story composition that firms prefer. As an illustration, consider the example setup in Section 3.2 (utility $u_A(x) = x$ over topics $A$ and $u_B(x) = 2x^2$ over topic $B$). Compare the following two sets of stories,

$$S = \{(1, z_1^A), (1, z_2^A), (1, z_3^A)\} \text{ and } \widetilde{S} = \{(0.3, z_1^A), (0.7, z_3^A), (2, z_3^A)\}.$$

Sets $S$ and $\widetilde{S}$ are identical in terms of total newsworthiness from the reader’s perspective. The only difference is in the fundamental news composition, or the way the stories are delivered. However, media firms do not view these states of the world as equivalent. They are not concerned with total newsworthiness, but with how much readership they can obtain. Sets $S$ and $\widetilde{S}$ differ in how “suspenseful” they are; in this case, $S$ contains an equal amount of information in every story, while $\widetilde{S}$ does not.

We can define a strict ordering over such stories that is similar in spirit to first-order stochastic dominance. In particular, consider two sets of stories $S = \{\lambda_1^k, z_1^k\}, \ldots, \{\lambda_N^k, z_N^k\}$ and $\widetilde{S} = \{\lambda_1^\widetilde{k}, z_1^\widetilde{k}\}, \ldots, \{\lambda_N^\widetilde{k}, z_N^\widetilde{k}\}$, where $S$ consists only of topic $k \in K$, and $\widetilde{S}$ only of topic $\widetilde{k} \in \overline{K}$. Topics $k$ and $\widetilde{k}$ need not be the same. For notational convenience, suppose that the indices are ordered by increasing newsworthiness, $\lambda_1^k \leq \ldots \leq \lambda_N^k$ and $\lambda_1^\widetilde{k} \leq \ldots \leq \lambda_N^\widetilde{k}$. Since the two topics may be different, we compare the total newsworthiness using utility as a metric to allow for comparisons. Then, suppose that the total newsworthiness is the same in sets $S$ and $\widetilde{S}$, which translates to having the total utility of all stories be the same, $u_k(\sum_{i=1}^N \lambda_i^k) = u_\widetilde{k}(\sum_{i=1}^N \lambda_i^\widetilde{k})$. Then, if $u_k(\sum_{i=h}^N \lambda_i^k) \geq u_\widetilde{k}(\sum_{i=h}^N \lambda_i^\widetilde{k})$ for each index $h \in \{1, \ldots, N\}$, we say that the set of stories $S$ holds more suspense potential than $\widetilde{S}$ (written $S \succeq_{SP} \widetilde{S}$, where $\succeq_{SP}$ represents a partial order over sets of stories understood as states of the world).\(^{21}\)

If the sets of stories $S$ and $\widetilde{S}$ are on the same topic, then the comparison does not require invoking the utility functions $u_k$, as newsworthiness need not be converted across topics. The comparison in this case is simply that $S$ holds more suspense potential than $\widetilde{S}$ if $\sum_{i=1}^N \lambda_i^k = \sum_{i=1}^N \lambda_i^\widetilde{k}$ and $\sum_{i=h}^N \lambda_i^k \geq \sum_{i=h}^N \lambda_i^\widetilde{k}$ (or, as an alternative condition, $\sum_{i=1}^h \lambda_i^k \leq \sum_{i=1}^h \lambda_i^\widetilde{k}$), for each index $h \in \{1, \ldots, N\}$, where $h$ is again indexed by increasing newsworthiness. The parallel with

\(^{21}\)The first condition that $u_k(\sum_{i=1}^N \lambda_i^k) = u_\widetilde{k}(\sum_{i=1}^N \lambda_i^\widetilde{k})$ is not required for our results and can be dropped; we mention it only for the total content of the sets of stories to be the same. The term “suspense” is also used, in a different manner and context, in Ely, Frankel and Kamenica (2013).
the notion of first-order stochastic dominance is immediate.

There are two dimensions to the notion of dominance by suspense potential ($\geq_{SP}$). The first is that within a topic, one set of stories is constituted in a more suspenseful way than another. The second is that across topics, the curvature of the utility function also affects potential for suspense. The more convex the utility function, or the higher the curiosity preferences, the higher the suspense potential. The following result then holds (the more general result in which the state of the world need not consist of only one topic is deferred to the Appendix):

**Proposition 7 (Firm profit and suspense potential).** Let $\Gamma(S)$ and $\Gamma(\tilde{S})$ be games with one state of the world, $S$ and $\tilde{S}$, respectively, that are otherwise equal, with large switching costs $\nu_{SW} > \tilde{\nu}_{SW}$ for some $\tilde{\nu}_{SW} > 0$, and with $u''_k(\cdot) \geq 0$, for $k \in K$. If $S \geq_{SP} \tilde{S}$, then there exists $\nu_{SK} \in [0, \nu_{RD}]$ such that firms make more profit in $\Gamma(S)$ than in $\Gamma(\tilde{S})$, provided that skipping costs are sufficiently large ($\nu_{SK} \geq \nu_{SK}$).

In words, if skipping costs are not too small, then firms benefit from having more suspense potential. Intuitively, if firms know that readers will not skip, then firms can hold them in suspense and delay the more important stories for longer, providing more distractions in the meantime. Firms can then take advantage of states of the world with more suspense potential. Notice that, for high enough suspense potential, there are fewer stories that readers would like to read since newsworthiness is more concentrated. But, with high enough skipping costs, firms can drive a larger wedge between what readers wish to read and what they do read, and even though their desire to read diminishes, the amount they read increases.

Since suspense potential contains dimensions of both news composition and preferences, this result has several implications. The first is in terms of preference for news arrival. To the extent that firms can impact news production, they would influence the way stories are packaged. This power of influence depends on the fundamental properties of the stories themselves and on the media type; online news aggregators, for instance, have arguably little direct impact on news production. Second, firms prefer stories from topics that induce higher curiosity preferences (political scandals, entertainment and so forth), ceteris paribus, unless skipping costs are very low. Moreover, all else being equal, media platforms with greater skipping costs are more effective than those with smaller skipping costs at promoting topics with high suspense potential.

### 3.4 Heterogeneous Readers and Targeting

Targeting, or the possibility of using consumer profile data to deliver individualized or “targeted” content (as well as advertising), is a main innovation of the internet, distinguishing it from traditional media.\(^\text{22}\) Although not yet fully developed, it can be viewed as a justification for the assumption of homogeneous readers made throughout the paper. Here, we briefly consider

\(^{22}\text{See, e.g., Athey and Gans (2010), Bergemann and Bonatti (2011), Athey et al. (2012) and Levin (2013); see also Pariser (2011).}\)
the case of heterogeneity and show that if consumers differ in their cost functions, then the inability to target them can lead to differentiation in the rankings; also, equilibrium rankings need not be in the reverse order of newsworthiness. Finally, we also show that the ability to target consumers can make each consumer type worse off.

**Anti-coordination and non-reverse-ranking in the headlines.** In Section 3.2, profit-maximizing outlets fully coordinate on the ranking of stories as a consequence of firm symmetry and consumer homogeneity. With heterogeneity, firms may differentiate, especially when they have limited ability to target their news coverage to individual readers. As an example of heterogeneity relevant to our analysis, readers can have different time costs of switching. For instance, readers with busy work schedules might face relatively high time costs, while young and technologically savvy readers might face relatively low switching costs. More generally, differentiation may also occur when readers have different preferences over topics.

**Targeting as non-welfare enhancing technology.** Suppose that firms have the ability to deliver individualized content to readers of a given type. While generally considered beneficial for media (and advertising) firms, it can also be beneficial for readers with specialized interests. Nonetheless, we briefly show that this need not always be the case. Specifically, we show that the possibility of targeting when readers differ in preferences can be worse for all types of readers, while increasing firms’ payoffs.

Consider two reader types of mass 1/2 each, and suppose that there are now three topics, A, B, and C. Readers have utility functions and costs similar to those in the example in Section 3.2, but with heterogeneity in preferences; i.e., $u_A(x) = u_B(x) = x$ for both types, and for type 1, $u_B(x) = 2x^2$ and $u_C(x) = 0$, while for type 2, $u_B(x) = 0$ and $u_C(x) = 2x^2$. They have identical costs of time $c_1(\tau) = c_2(\tau) = 4\tau^3$, and identical reading costs $\nu_{RD}^1 = \nu_{RD}^2 = 0.3$. Assume prohibitively high skipping and switching costs $\nu_{SK}^1 = \nu_{SK}^2$, $\nu_{SW}^1 = \nu_{SW}^2$. There is one state of the world,

$$S = \{(1, z_1^A), (0.8, z_2^A), (0.456, z_1^B), (0.455, z_2^B), (0.454, z_3^B), (0.456, z_1^C), (0.455, z_2^C), (0.454, z_3^C)\}.$$

The preferred outcome of a type 1 reader is to read just the two stories $(1, z_1^A), (0.8, z_2^A)$, followed by reading just the three stories $(0.456, z_1^B), (0.455, z_2^B), (0.454, z_3^B)$. For a type 2 reader, the preferred outcome is to read just $(1, z_1^A), (0.8, z_2^A)$, followed by reading just $(0.456, z_1^C), (0.455, z_2^C), (0.454, z_3^C)$.

When targeting is not possible, the firm places stories $(0.8, z_2^A), (1, z_1^A)$ first, as it will lose either type 1 or type 2 readers if it places either topic B or C first. All consumers then receive their preferred ranking. However, when targeting is possible, the firm places $(0.454, z_3^B), (0.455, z_2^B), (0.456, z_1^B)$ first for type 1 readers and $(0.454, z_3^C), (0.455, z_2^C), (0.456, z_1^C)$ for type 2 readers. Both types then read the first three stories, and they are strictly worse off with targeting. Hence, as this example illustrates, targeting may not always be in the readers’ interests.
3.5 Uncertainty

We now relax the assumption that there is just one state of the world. We show that uncertainty can be beneficial to firms, as it provides them with an additional tool for attracting more readership. In particular, firms can entice consumers to read stories that they otherwise would avoid, in the hope of eventually reading an important story. Uncertainty can therefore exacerbate the reader inefficiencies mentioned above.

As an illustration, consider again the example with $u_A(x) = x$, $u_B(x) = 2x^2$, with $d = 6$, $\nu_{RD} = 0.3$, prohibitively high switching cost $\nu_{SW}$, and a high skipping cost $\nu_{SK}$. Assume that there are two states of the world, $S = \{S_1, S_2\}$, where the states:

\[
S_1 = \{(2, z_1^A), (1.2, z_2^A), (0.7, z_1^B), (0.45, z_2^B), (0.3, z_3^B)\}
\]

\[
S_2 = \{(2, z_1^A), (1.2, z_2^A), (1, z_1^B), (0.45, z_2^B), (0.3, z_3^B)\}
\]

occur with probabilities $p$ and $1 - p$, respectively. A reader-optimal ranking would be

\[
\sigma^*(S) = \begin{cases} 
\{(2, z_1^A), (1.2, z_2^A), (0.7, z_1^B), (0.45, z_2^B), (0.3, z_3^B)\} & \text{if } S = S_1 \\
\{(1, z_1^B), (0.45, z_2^B), (0.3, z_3^B), (2, z_1^A), (1.2, z_2^A)\} & \text{if } S = S_2,
\end{cases}
\]

according to which a consumer reads $(2, z_1^A)$ and $(1.2, z_2^A)$ in state $S_1$ and $(1, z_1^B), (0.45, z_2^B)$ in state $S_2$.

If there were no uncertainty (meaning that the state of the world were known to be either $S_1$ or $S_2$), then the firms would not be able to make the readers read more than they prefer to in state $S_1$. But with uncertainty, the firms can in fact make the consumers read more in both states of the world. To see this, suppose that each firm ranks the stories according to the following strategy:

\[
\tilde{\sigma}(S) = \begin{cases} 
\{(0.3, z_3^B), (0.45, z_2^B), (0.7, z_1^B), (2, z_1^A), (1.2, z_2^A)\} & \text{if } S = S_1 \\
\{(0.3, z_3^B), (0.45, z_2^B), (1, z_1^B), (2, z_1^A), (1.2, z_2^A)\} & \text{if } S = S_2.
\end{cases}
\]

In equilibrium, the reader considers only two actions that are not strictly dominated. His two options are: (i) to read all three stories, regardless of the state, and (ii) not to read any story at all.\(^{23}\) Recall that by Lemma 1, it suffices to consider the ex-ante stage, since the agent is dynamically consistent and does not deviate in future periods from his plan of action. Furthermore, by Lemma 2, the agent maximizes expected utility $E[u_A(R^A) + u_B(R^B) - c(\tau)]$.

\(^{23}\)Not reading any story yields zero utility, which is preferred, in state $S_1$, to reading the stories in the given order in which they are presented. Recall that we are assuming a high skipping cost (i.e., $\nu_{SK} \rightarrow \nu_{RD}$).
In option (i), his final history is:

\[ H_T^{(i)}(S) = \begin{cases} 
\{RD(0.3, z_3^B), RD(0.45, z_2^B), RD(0.7, z_1^B), ST\} & \text{if } S = S_1 \\
\{RD(0.3, z_3^B), RD(0.45, z_2^B), RD(1, z_1^B), ST\} & \text{if } S = S_2,
\end{cases} \]

with expected utility \( U^{(i)} = pu_B(1.45) + (1 - p)u_B(1.75) - c(3\nu_{RD}) \), while in option (ii), his final history is \( H_T^{(ii)} = \emptyset \), with expected utility \( U^{(ii)} = 0 \). It is straightforward to show that there is a threshold \( \hat{p} \) (more precisely, \( \hat{p} \approx 0.91 \)) such that, for \( p < \hat{p} \), the reader will read all three stories of topic B in both states of the world (in which case, \( \sigma_1 = \sigma_2 = \bar{\sigma}(S) \) is an equilibrium). This holds even though the readers will receive strictly negative ex-post utility in state 1, implying that they would have preferred not reading any story. This result confirms the intuition that, if media markets do not deliver the reader-efficient ranking when there is just a single state of the world, then a similar, and perhaps more pronounced, implication holds with uncertainty as well.\(^{24}\) Note once more that the result does not rely on any manipulation of the readers’ beliefs; they are rational, dynamically consistent and fully aware of the firms’ choices.

The result that firms can use uncertainty as a tool for consumers to read more does not hinge on curiosity preferences. However, once readers have become aware that they are in state of the world \( S_1 \), they still keep reading on topic B, even though they would not have read these stories had they been aware of the state beforehand. This feature does rely on curiosity, since the readers have now acquired a taste for topic B. They not only prefer reading more on topic B, but they also prefer reading more from that topic to their ex-ante favorite story, \((2, z_1^1)\) from topic A. The added utility, net of cost, from reading A is 2, while the added utility from reading from topic B is 3.08.\(^{25}\) That is, topic B has crowded out their preference for topic A.

**Surprises and breaking news.** If, instead, the probability of the state with highly newsworthy stories is sufficiently low (state \( S_2 \) in the example), then uncertainty may play a different role. It may lead firms not to follow the ‘best for last” strategy in their rankings if readers don’t expect there to be a good story at the end. For instance, suppose, for simplicity, that states \( S_1 \) and \( S_2 \) have content only from topic B, namely, \( S_1 = \{(0.2, z_1^B), (0.2, z_2^B), (0.2, z_3^B), (0.2, z_4^B)\} \) , which occurs with probability \( p \), and \( S_2 = \{(0.2, z_1^B), (0.2, z_2^B), (0.2, z_3^B), (1.4, z_4^B)\} \) , which occurs with probability \( 1 - p \). In state \( S_1 \), the consumer prefers not reading any articles at all, while in state \( S_2 \) he prefers reading story \((1.4, z_4^B)\) and one additional story with content 0.2. Consider the following strategy:

\[ \bar{\sigma}(S) = \begin{cases} 
\{(0.2, z_1^B), (0.2, z_2^B), (0.2, z_3^B), (0.2, z_4^B)\} & \text{if } S = S_1 \\
\{(0.2, z_1^B), (1.4, z_4^B), (0.2, z_3^B), (0.2, z_2^B)\} & \text{if } S = S_2.
\end{cases} \]

\(^{24}\)This is consistent with results from the empirical search literature, (e.g., Jeziorski and Segal, 2012).

\(^{25}\)The calculation for topic A is \( \Delta u_A^t(2,0) = u_A^t(2) - u_A^t(0) = 2 \), and for topic B it is \( \Delta u_B^t(1.45,0.75) = u_B^t(1.45) - u_B^t(0.75) = 3.08 \).
As in the previous example, there is a threshold \( \bar{p} \) (specifically, \( \bar{p} \approx 0.98 \)) under which the reader is willing to read even in state \( S_1 \). But for any \( p > \bar{p} \), the reader prefers not to read at all. Hence, for \( p > \bar{p} \), this strategy cannot be an equilibrium. The only way for the reader to know that he is in state \( S_2 \) is for the firm to put story \((1.4, z^B_4)\) first.\(^{26}\) That is, the firm follows this strategy:

\[
\sigma'(S) = \begin{cases} 
(0.2, z^B_1), (0.2, z^B_2), (0.2, z^B_3), (0.2, z^B_4) & \text{if } S = S_1 \\
(1.4, z^B_4), (0.2, z^B_1), (0.2, z^B_2), (0.2, z^B_3) & \text{if } S = S_2.
\end{cases}
\]

The consumer, then, does not read in state \( S_1 \), and reads two stories \((1.4, z^B_4), (0.2, z^B_1)\), in state \( S_2 \). Note that in this case, the firm does not put the best story last, of those that are read. In other words, in the case of a very surprising, “breaking news” item, as in this example (where it occurs with < 2% probability), firms must signal to the readers that this rare event has taken place.

4 Applications and Further Results

We now discuss diverse aspects of the media that simple extensions of our baseline framework naturally address. Rather than providing a detailed analysis, our aim is to illustrate how the framework can be adapted in each case. The applications range from advertisement placement, targeting, search, aggregators and social media, to public media and voting. We also use our theory to briefly compare rankings across different media types.

4.1 Advertising Segments

Advertising can affect media consumption through the time costs that it imposes to view or skip commercials, as well as through the screen space it takes away from news stories. Our framework can be extended to incorporate these factors.\(^{27}\) For instance, we can introduce commercials as stories with a reading cost attached, but with near-zero newsworthiness. We can further assume, as is increasingly the case in online media, that firms use forced-view advertising, which obliges consumers to “see” the commercial before advancing through the website. Alternatively, advertising can be modeled as imposing an increased cost of reading and skipping. The latter modeling option is suitable for advertisements that appear on the sides of web pages, thereby diminishing the ease with which consumers can read or skip articles. In

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\(^{26}\)Recall that the reader observes only newsworthiness; he does not observe \( z \). Effectively, the reader cannot observe content until he has read the story.

\(^{27}\)In doing so, we abstract from models in which advertising can distort the type and quality of reporting, such as in George and Waldfogel (2003), Hamilton (2004), Ellman and Germano (2009) and Germano and Meier (2013), and two-sided market models in which advertising causes a general disutility of consuming media programs, as in Anderson and Coate (2005) and Wilbur (2008). Instead, we focus specifically on the time dimension.
either case, advertising can be seen as creating a disutility in the form of an additional time cost of viewing advertisements or, indirectly, of skipping or reading articles.

Our model can then be applied to analyze advertising premia in different environments. Since time costs and constraints vary with media type, our previous analysis suggests that optimal reporting and advertising strategies might vary across media types. Below, we illustrate how, within a game expanded to allow for advertising segments, such different strategies might arise.

Consider a game $\Gamma_{AD}$ in which we allow firms to include short advertising segments that cannot be avoided to advance through a website. Viewing an advertisement leads to a fixed additional cost of $\nu_{AD}$. A media firm obtains revenues, $r_{AD} \geq 0$, from a consumer who views an advertising segment. These revenues are added to the profit function in Section 2. In this extended game, media outlets must choose where in the website, if anywhere, to insert unavoidable advertisement segments. They face a tradeoff between the increased profits from the advertisement and the possible decrease in news consumption due to the additional cost incurred by readers.\(^ {28}\)

As in the examples of Section 3, suppose that a reader has utility functions $u_A(x) = x$ and $u_B(x) = 2x^2$ over topics A and B, respectively. Let the time cost be $c(\tau) = d\tau^3$, where $d > 0$ is a parameter, and assume for the moment that $d = 3$. Let $\nu_{RD} = 0.3$, $\nu_{SK} = 0.05$, and $\nu_{AD} = 0.11$. Assume that $\nu_{SW}$ is sufficiently large so that each firm is effectively a monopoly. Let also $r_{AD} = 1.1$, so that the firm strictly prefers having the reader view one more commercial to having him read one more story. Suppose that the firm cannot place two commercials in a row; we make this simplifying assumption to capture that readers may turn to other activities while waiting for the commercial to end.

Consider first the case in which the only state of the world is

$$S = \{(3, z_1^A), (3, z_2^A), (3, z_3^A), (3, z_4^A)\}.$$ 

All stories have equal newsworthiness so that the ranking is of no importance. Without advertising, the consumer reads four stories and receives utility 6.82.\(^ {29}\) With advertising, the firm chooses strategy

$$\sigma = \{AD, (3, z_1^A), AD, (3, z_2^A), (3, z_3^A), (3, z_4^A)\},$$

where $AD$ refers to the placement of an advertising segment. The consumer now reads three stories and views two advertisements. It is clear that the firm will place an advertising segment at the very beginning, as is commonly observed on websites. It then reduces the number of

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\(^ {28}\)While we make the modeling assumption that readers must view the advertisement before proceeding, our framework can clearly be extended to also allow the advertisement to be part of the story itself. For instance, we can assume that a story with an advertising segment would cost $\nu_{RD} + \nu_{AD}'$ to read, where $\nu_{AD}' > 0$, and that the firm’s profit from this story being read would be $1 + r_{AD}'$.

\(^ {29}\)To be fully consistent with our assumption, the state of the world would include more stories than the consumer would read; we omit these for simplicity.
advertisements as the reader goes further down the ranking. It cannot place an advertisement before the third story, as the reader would then choose to stop reading after only two stories. Intuitively, the reader has less incentive to stay on the website as he reads, as there are fewer stories that he wishes to read in the future.

But suppose, instead, that the only state of the world is

\[ S = \{(0.5, z^B_1), (0.5, z^B_2), (0.7, z^B_3), (0.7, z^B_4)\} \]

It is made up of only complementary stories (i.e., on topic \( B \)). Without advertising, the consumer reads four stories, as in state \( S \). He receives utility 6.34, which is less than he would have received in state \( S \) when there is no advertising. Nevertheless, the firm can still make more advertising revenue in state \( S \). The firm’s strategy is now

\[ \tilde{\sigma} = \{AD, (0.5, z^B_1), AD, (0.7, z^B_2), AD, (0.7, z^B_3), (0.5, z^B_4)\}, \]

and the consumer reads three stories and views three advertisements. The firm still places an advertisement at the very beginning, but now it can also place an advertisement near the end of the relevant ranking, i.e., before the last story read. From a welfare perspective, note that when advertisements are allowed, the reader obtains less utility in \( \tilde{S} \) than in \( S \). Therefore, the firm makes more profit in state \( \tilde{S} \) than in state \( S \), as it can obtain more advertising revenues, despite the reader’s utility over the stories read, net of advertising, being smaller. It is then immediate that in a state of the world in which the firm has a choice between stories from both topics, it would prefer to display stories on topic \( B \) and make more advertising revenue, even when the total number of stories consumed is the same for both topics.

To analyze the effect on advertising of different time constraints, we allow the parameter \( d \) to change. As \( d \) increases, the firm places fewer advertisements. For instance, if \( d = 4 \), then the firm’s strategy in state of the world \( \tilde{S} \) is given by \( \tilde{\sigma}' = \{AD, (0.5, z^B_1), AD, (0.7, z^B_2), (0.7, z^B_3), (0.5, z^B_4)\} \). The consumer then reads three stories and views two advertisements. The result that the reader views fewer advertisements as his time constraint increases is robust (up to integer problems).\(^{30}\)

**Suspense Potential and Advertising.** In the example above, firms employ suspense, as formally defined in Section 3.3, to keep readers through an advertisement to see the end of a story.\(^{31}\) This result is general. Specifically: *if a set of story \( \tilde{S} \) holds more suspense potential

\[ \tilde{S} \preceq SP \ S \]

\[ \Rightarrow \]

\[ \tilde{\sigma} = \{AD, (0.5, z^B_1), AD, (0.7, z^B_2), AD, (0.7, z^B_3), (0.5, z^B_4)\}, \]

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than a set of story S (\(S \succeq_{SP} S\)), then, for high enough skipping and switching costs, the firm places (weakly) more advertisements and makes (weakly) more profit.

4.2 Restoring Reader Efficiency

Having shown that equilibrium rankings can be far from reader-efficient ones, we now sketch how profit-maximizing firms can be induced to restore reader-efficient rankings. We consider two distinct possibilities. The first is through the presence of a public media firm in the market that maximizes consumer preferences, and the second is by introducing access fees to be charged to consumers. The latter is effective only if readers’ willingness to pay for efficient rankings is sufficiently large relative to what their viewership, colloquially referred to as “eyeballs,” is worth to advertisers.

**Public Media.** The value of public media has been an intense subject of debate in recent years, even generating extensive attention during the 2012 US presidential campaign, and culminating in candidate Mitt Romney’s well-publicized comment that he would stop government funding of the public broadcasting television network *PBS (Public Broadcasting Service)* if elected.\(^{32}\)

Therefore, we look at public media within the context of our model. We add a *public media firm* and assume that it maximizes the utility of the average viewer. In our present application with homogeneous readers, it is straightforward to show that the public outlet always directly chooses the reader-efficient ranking. More importantly, however, when such a public firm is present in the market with other firms and with low reader switching costs, then *all* equilibria are reader-efficient.\(^{33}\)

**Proposition 8 (Public media and reader efficiency).** *For any given game \(\Gamma\), where one of the media firms is a public one, there exists a \(\bar{v}_{SW} > 0\) such that for any \(v_{SW} < \bar{v}_{SW}\), every Nash equilibrium of \(\Gamma\) is reader-efficient.*

To the extent that a social planner aims to implement the reader-efficient equilibrium, this result provides a benchmark of how it can be achieved in our framework with homogeneous readers. Note that the presence of an easily accessible public outlet does not imply that it captures the market from other outlets. In equilibrium, no consumer switches outlet, even in the case of low switching costs. Rather, the presence of the public firm changes the equilibrium above holds. Moreover, this replacement is not required for the definition of suspense potential provided in the Appendix. The general result is consistent with well-known empirical observations.

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\(^{32}\)This is frequently referred to as the “Big Bird” comment:

“I’m going to stop the subsidy to *PBS* [...] I like *PBS*. I love Big Bird. [...] But] I’m not going to keep on spending money on things to borrow money from China to pay for.”

This comment has been widely covered and discussed; for instance, it is first on *Google’s* list of “trending” US political gaffes of 2012, and has led to a quarter million “Tweets” on *Twitter*. See Benson and Powers (2011) for a comparative study of public media in 15 OECD countries.

\(^{33}\)Recall from Proposition 3 that the existence of a reader-efficient Nash equilibrium is guaranteed for a sufficiently small switching cost.
itself; all firms choose to provide a reader-efficient ranking. The public media firm effectively sets a standard that other outlets must adhere to.

We emphasize, however, that public outlets in our setting, by assumption, maximize reader preferences. In practice, this may not always be the case. Arguably, public media that are paid directly by the consumers or that are funded with public money enforce some degree of accountability towards consumer preferences. But at one extreme, public media may place higher weight on public affairs than readers do, perhaps out of concern for social efficiency. At the other, state-owned outlets may have very different incentives.34

**Prices and Access Fees.** We now study the effect of allowing media firms to charge a price for readers to access their websites. Introducing fees may change the ranking chosen towards a more reader-efficient one, depending on the relation of how much firms can charge consumers versus what they can get from advertisers.

Suppose that each firm \( i \in I \) can charge a fixed access fee, \( p^i \geq 0 \), in stage 0 of the game (formally, to the editorial policy \( \sigma^i \) of game \( \Gamma_{ext} \), and hence, \( \Gamma \) as well). This adds a fixed (state-independent) viewer fee component, the sum of all fees received, to the profit function in Section 2. The reader’s expected utility function is as before, except that the fee \( p^i \) is now subtracted when the reader accesses firm \( i \)’s website for the first time. Let \( \sigma^* \) and \( \hat{\sigma} \) denote, respectively, the reader-efficient ranking and the ranking that a monopolist would choose in the standard model without prices, and let \( P^* \) and \( \hat{P} \) be the corresponding ex-ante plans of actions of the readers, leading to utilities \( U_0(P^*|\sigma^*) \) and \( U_0(\hat{P}|\hat{\sigma}) \), respectively. Assume, for simplicity, that \( P^* \) and \( \hat{P} \) involve different numbers of stories read.

Consider first the case of prohibitively high switching costs, for which each firm is effectively a monopolist. A firm then faces a trade-off between giving a ranking preferred by the reader, thus being able to charge a higher access fee but losing revenue from the diminished number of stories read, and selecting a ranking with a higher number of stories read but charging a lower access fee. We distinguish two opposing cases:

(i) if the utility gain from receiving reader-efficient stories is sufficiently large relative to the revenues that the firm obtains from advertisers (the price per story read by a unit mass is implicitly set to one in our baseline profit function from Section 2.2), then the optimal strategy is to choose the (reader-efficient) ranking \( \sigma^* \) and charge a fee of \( \hat{p} = U_0(\hat{P}|\hat{\sigma}) \);

(ii) if the utility gain from receiving reader-efficient stories is sufficiently small relative to the price paid by advertisers, then the firm’s optimal strategy is to choose the (monopoly) ranking \( \hat{\sigma} \) and charge a fee of \( \hat{p} = U_0(\hat{P}|\hat{\sigma}) \).

34Interestingly, public media in established democracies often have higher levels of trust from the public; for instance, BBC news typically ranks at the top with an important margin in the UK (http://www.pressgazette.co.uk/node/45249); PBS, despite its relatively smaller viewership, also ranks high in polls in the US (http://www.pbs.org/about/news/archive/2013/pbs-most-trusted/); see also Ladd (2012) and Tsfati and Ariely (2013). However, caution should be exercised in interpreting these results without further empirical analysis on the direction of causality and the underlying causes.
In both cases, the firms appropriate all the consumer rent, and the difference lies in which ranking is provided to the viewers. Whether the firms choose the reader-efficient ranking ($\sigma^*$) or the monopoly ranking ($\hat{\sigma}$) in equilibrium depends on the relation between advertising revenue and the reader’s added willingness to pay to read his most preferred stories.

The other extreme of zero switching costs (perfect competition) also contains the two opposing cases. At the profit-maximizing equilibrium, in case (i), firms choose the reader-efficient ranking $\sigma^*$, and in case (ii), they choose the monopoly ranking $\hat{\sigma}$. The difference, however, is that they charge zero fees in both cases.\(^{35}\) Note, too, that Proposition 8 of the previous section also extends to the setting with access fees. If the switching cost is zero, then the reader-efficient ranking $\sigma^*$ is again chosen by all outlets in either case, regardless of readers’ willingness to pay relative to their value for advertisers.

### 4.3 Different Media Types and Platforms

The essential features of our model are that consumers do not see all the news at once and therefore follow an order when accessing stories, that they incur reading, skipping and switching costs, and that media firms account for these factors in their display of the news. While we have focused on online newspapers, these attributes hold for most media types, including television, radio, print newspapers, magazines, social media and digital platforms accessed through tablets and smartphones. Thus, our framework applies to this wide array of media as well. In some cases, such as broadcast television and radio, the model can be adapted in a simple way, and the main differences between media types lie in the magnitudes of the different costs. In other cases, such as social media and search engines, our model must first be extended in the manner described below.

**Traditional media.** While equilibria typically avoid both skips and switches in the case of homogeneous readers, as shown in Proposition 5, this does not imply that these costs are irrelevant. On the contrary, as illustrated in Section 3, the sizes of these costs are crucial in determining the equilibrium rankings. Furthermore, the story rankings that firms choose also depend on consumers’ time constraints, which may also vary across media types. Therefore, when comparing media, it is useful to focus on the comparative statics as both the technological costs of the media and time constraints vary, while abstracting away from other existing differences.

Consider, for instance, broadcast television and radio. In both cases, while the switching costs may be relatively low, the skipping costs can be high, and may even approach the reading cost of viewing or sitting through a whole story. Proposition 2 suggests that such higher costs may lead to a stronger misalignment between the equilibrium rankings provided by the firms and the ones preferred by the viewers, and Proposition 7 implies that they have a greater ability

\(^{35}\)For brevity, we do not consider intermediate switching costs, which contain similar mechanisms. We also note that the cutoffs for cases (i) and (ii) may not be the same for the monopoly and perfect competition cases, as they depend on the switching costs.
to use the stories’ suspense potential. To the extent that the skipping costs are lower in online media, this may explain part of the migration of viewers away from television and radio to online news consumption (see, e.g., Pew Research Center, 2012).\textsuperscript{36}

Based on our discussion in Section 4.1, we also conjecture that there may be more advertisements on television and radio than on media with lower skipping costs. While we do not conduct an empirical analysis, we note that the United States and other countries have passed legislation specifically regulating the amount of advertising broadcast on television and radio (see e.g., Anderson and Coate, 2005), and the caps imposed are often binding. Our results suggest that this form of regulation should be particularly important for media technologies for which skipping costs are high. As an illustration, it is clear from the examples in Section 3 that for low enough skipping costs, the distance between equilibrium and reader-efficient rankings would be reduced. We also note that a number of television and radio programs are now available online with significantly lower skipping costs, thereby indicating a possible estimation strategy for an empirical analysis of the comparative statics across costs.

**Online aggregators.** News aggregators have recently gained prominence in the online media market, and including them in our analysis seems worthwhile for understanding online news provision and consumption. Our basic framework can be viewed as a model between aggregators rather than between media outlets. The assumption that media outlets’ strategy is reduced to one of ranking given stories is particularly natural for aggregators, as they have very low marginal cost of obtaining news stories. The main insights of our model, therefore, also hold in a setting with aggregators.\textsuperscript{37} We note, however, that incentives of news aggregators may be different from those of news producers, which could impact their choice of rankings. Moreover, some aggregators offer clients the possibility of personalizing their rankings and “feed filtering” to some extent. By allowing readers to choose directly their preferred news sources by topic and other preference criteria, they effectively enable them to mold their own “editorial policy” on a variety of subjects of interest. These platforms allow readers to circumvent, to some degree, the rankings provided by official news sites. They are particularly relevant when there is significant uncertainty in the possible stories and media items that can be consumed. A full analysis that includes both news-producing outlets and aggregators in a context of time-constrained consumers is left for further research.

**Search.** Search engines, such as Google and Yahoo! currently have a significant presence in online media, and their share of advertising revenue has grown rapidly in recent years (see, e.g., Grueskin et al., 2012). A simple way to embed search into the basic framework is as follows. In

\textsuperscript{36}An audience migration away from the traditional media may, over time, induce them to provide more reader-efficient rankings as well.

\textsuperscript{37}Hong (2011), Athey and Möbius (2012), George and Hogendorn (2012, 2013), Jeon and Esfahani (2012), Jordan et al. (2012), Calin et al. (2013), and Dellarocas et al. (2013), study aggregators in settings without time constraints.
addition to reading, skipping, switching and stopping, readers can also decide to search. This can be modeled as a choice similar to skipping or switching in that it generates a time cost, \( \nu_{SE} > \nu_{SK} \), of performing the search. After the search, the reader can choose to read the story on the outlet to which he is directed or to skip it, continue searching, switch, and so forth. An in-depth analysis of search requires the introduction of outlets that specialize in search services and have well-specified rules of linking to stories on different outlets. An efficient search engine can potentially also be a useful tool for readers to circumvent the rankings provided by the media outlets, thereby enabling them to consume stories closer to their preferred bundle.\(^{38}\)

**Social media.** Social networks and forums, such as Twitter, Facebook, Gawker, and blogs in general, have risen in popularity as alternatives to traditional media. Accounting for their richness and the different aspects and alternatives that exist is outside the scope of this paper. Nonetheless, a number of these platforms maintain a degree of control over the manner in which news is displayed. Facebook, for instance, has a newsfeed which provides users with a ranking of postings. It also increasingly intersperses the newsfeed with advertisements, precisely in the manner discussed in Section 4.1. To the extent that their incentives may also be to keep consumers reading more “news” stories, similar tensions to the ones described here may persist. That is, the possible misalignment between ranking stories according to the consumers’ preferences and keeping consumers connected longer would remain. Moreover, other platforms, including Twitter, also allow news producers (including The New York Times and CNN, among many others) to have accounts to which users can subscribe. The insights of our results then hold in these settings as well; a detailed theoretical and empirical analysis of this market would be of interest.\(^{39}\)

### 4.4 Political Outcomes and Time-Constrained Voters

The results of Section 3 point to an important aspect of ranking equilibria, namely that even a small direct utility loss can be associated with a large difference between equilibrium rankings and reader-efficient rankings. When story informativeness is introduced, this observation implies that readers may acquire very different information from what they would prefer. In particular, while consumers read more than they wish to, they may remain less informed on the relevant subjects. In a political economy setting in which informativeness plays a crucial role in voting outcomes, misdirected information acquisition may have significant consequences. That is, in addition to direct reader inefficiency, the informational externalities can lead to a substantial

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\(^{38}\)For studies of search engines, see White (2009), de Cornière (2011), and Taylor (2013), who analyze the performance search engines with respect to advertised products; see Hagiu and Jullien (2011, 2013), de Cornière and Taylor (2012), and Burguet et al. (2013) for an analysis of the incentives of intermediaries to favor certain searches over others; and see Edelman and Lockwood (2011) and Wright (2011) for empirical evidence of bias in search engines on the web.

\(^{39}\)Hong (2012) studies the interplay of Twitter and mainstream news sites. Curran et al. (2012) and Lovink (2011) contain useful general analyses of social media; see also Pariser (2011).
social inefficiency. This reinforces a concern already expressed by Downs that even rational voters may not be adequately informed about public affairs issues (Downs, 1957; Bartels, 1996; and Hamilton, 2004).

We have not assumed any political bias in our model, and it is not required for the notion that readers may systematically be uninformed on politically important topics. Following the results in Section 3.3, this would be a direct implication from the empirical statement that entertaining and less politically relevant stories are on topics that induce curiosity preferences. In addition, even within politics, it would follow if sets of stories that have more suspense potential are also less important for voting decisions. Formally, we would simply require the addition of information content to stories. For brevity, we turn instead to the case in which firms are politically biased, and we explicitly introduce story content in that setting.

Media Bias. A large literature documents media bias and the degree to which, empirically, media firms systematically underreport or overreport on specific subjects (political or otherwise).40 Throughout the paper, we have assumed away any biases on the part of both firms and readers. Allowing bias in our model requires a simple change to the firms’ objective function; the discussion that follows does not depend on the specific form we use. We extend the firms’ profit functions in the following way:41

\[
\Pi_i(\sigma^i|\sigma^{-i}) = \sum_{k \in K} \sum_{n \in S^i_k} \mu^{k,i}_n(\sigma^i, \sigma^{-i}) + \sum_{k \in K} \alpha^i \sum_{n \in S^i_k} \mu^{k,i}_n(\sigma^i, \sigma^{-i}) \lambda^k_n z^k_n, \ i \in I,
\]

where now \(z^k_n \in \{-1, 0, 1\} \times N \times K\). Besides identifying the story and the topic as before, \(z^k_n\) also keeps track of the content of a story that, for simplicity, takes three values: \(-1\) for negative content, 0 for neutral content and +1 for positive content. Accordingly, \(\alpha^i_k \in \mathbb{R}\) captures firm \(i\)’s bias for readers viewing stories on topic \(k \in K\) weighted by newsworthiness and content. Recall that \(\mu^{k,i}_n(\sigma^i, \sigma^{-i})\) is the share of the readership that firm \(i\) receives on topic \(k\), and that \(\lambda^k_n\) is newsworthiness. Setting \(\alpha^i_k \neq 0\) indicates that firm \(i\) cares about which newsworthy stories consumers read. This is a proxy for information received by the readers; a more newsworthy story is also more informative, and the content variable \(z^k_n\) refers to the intrinsic information transmitted to readers. Hence, \(\alpha^i_k > 0\) for topic \(k\) captures bias for content in one direction (in favor of positive news content on topic \(k\)), and \(\alpha^i_k < 0\) captures a preference for content in the opposite direction, as with the case of a left-right political spectrum. This model therefore allows for political (or other) biased preferences by the firm. Note that, as in the rest of the model, the firms’ strategies consist only of ranking the stories; we have not extended the model to allow


41 See, for example, Ellman and Germano (2009) or Anderson and McLaren (2012) for microfoundations of related profit functions in Bayesian settings.
for slanting the content of stories. It is straightforward, then, to show that such preferences will influence the ranking of the stories as firms seek to emphasize or suppress information. Maintaining the assumption that consumers are aware of this process and of firms’ preferences, and that they are fully Bayesian rational, consumers still may not receive the stories and hence the information that they would like. Their posterior beliefs may be affected, even when they account for the firms’ strategies.

As an illustration, suppose that there is a monopoly firm \( i \) and two states of the world \( S_1 \) and \( S_2 \), where in \( S_1 \), story \((1, z_1^A)\) occurs, and in \( S_2 \), story \((1, z_2^A)\) occurs. Suppose that \( \alpha^i_A = 1, z_1^A = -1 \) and \( z_2^A = 0 \), meaning that the firm has a bias for readers not to receive the content of story \((1, z_1^A)\) in \( S_1 \), and is neutral over the content of story \((1, z_2^A)\) in \( S_2 \). Also assume that the content of the story is perfectly informative over a political event of importance to the reader. If the reader reads the story, in either state, then he knows exactly what political event has occurred and votes accordingly. Finally, assume that there are a number of identical, stories in each state, such as stories on topic \( B \), where \( \alpha^i_B = 0 \). Then, there is an equilibrium in which the firm places \((1, z_1^A)\) at the end of its ranking in \( S_1 \), and places \((1, z_2^A)\) at the end of its ranking in \( S_2 \). Skipping costs are such that the reader never accesses those stories in either state.

Consider a voter who votes one way given his prior and another when learning that he is, say, in state 1. Then, a biased media firm affects the reader’s vote, even though the reader is fully aware of the firm’s strategy beforehand. This shows that there may be a significant externality from the voters receiving reader-inefficient rankings, even when the direct utility cost of reading the “wrong” stories may be low.

Selecting media outlets. Consumers often prefer to read from outlets that share their views. For instance, Gentzkow and Shapiro (2010), in their empirical analysis of media slant, find strong evidence that readers have a preference for like-minded news. Behavioral models have been proposed to accommodate this notion, typically in a context of slant (e.g., Mullainathan and Shleifer, 2005). From an informational viewpoint, this preference has been viewed as puzzling, as it appears that readers have more to learn from reading news that does more than confirm their prior.

Our model provides a simple and intuitive explanation, which holds even in a setting without slant, for a preference to read from like-minded media outlets. Suppose that there is more than one firm to choose from, and that viewers do not have prohibitively high switching costs. Moreover, suppose that readers have heterogeneous informational priors. Then, whether or not there is also supply-driven heterogeneity in biases, the market outcome may be one of anti-coordination, as discussed in Section 3.4. Additional factors can be included in the firms’ profit function, such as a preference for readership of specific topics. For instance, viewers may be more receptive to advertisements when viewing sports news. This can be done by multiplying the first term of the profit function by a parameter \( \beta^i_k \), thus weighting readership differently according to the topic. The model can also be extended to allow a social welfare dimension to the firms’ objectives.

A recent article in The New Yorker remarks: “MSNBC and Fox News often express their differing political
the firm whose editorial policy is closest to their prior, as they believe that this firm will be less likely to “conceal” relevant information from them. In other words, readers here self-select to acquire news from outlets that “share” their views not because they have a preference for information that supports their beliefs, but rather because they can more easily access stories of interest.\footnote{It is straightforward to incorporate readers’ preference over the content they receive. We have so far assumed that utility is a function only of newsworthiness $\lambda_k$; we can include preferences for content by allowing utility to be a function of content $z_k$ as well, for topics $k \in K$.}

This discussion demonstrates that our framework can be extended in a straightforward way to include bias on both the firm and the consumer side of the market. This model would be instrumental in conducting a detailed theoretical and empirical analysis of markets with these properties and in disentangling the demand and supply effects.\footnote{Possible directions for empirical work include a formal analysis of reader page views and the order in which they read, as well as the analysis of measures of consumer trust in the media and the news gap. Boczkowski and Mitchellstein (2013) study the news gap in several countries; Ladd (2012) studies trust in the US news media and finds a dramatic decrease over the last four decades. See also Pew Research Center (2007a, 2007b).} We defer this analysis to future research.

\section{5 Closing Remarks}

To account for the overwhelming quantity of information available today, we introduce a framework in which consumers sequentially decide which stories to read and media firms effectively rank stories in each state of the world. This provides a unified theory that accommodates various media types and that captures the differences between media types through the basic technological costs of accessing and processing information. Although small when taken individually, these costs play a crucial role in understanding overall market behavior. We also formally define a notion of suspense potential and show that it plays in the firms’ favor both for increasing news readership and for placing commercials inside story rankings and news presentations more generally. The main insights of the theory are easily extended to various domains even outside the news media.

The framework further lends itself to the analysis of political economy settings in which interactions between the news media and time-constrained voters involve important informational externalities. Our model then provides a tractable tool for more extensive theoretical and empirical investigations of the media market and its political economy impact.
References


Appendix

A Proofs

A.1 Proofs of Lemmas 1 and 2

Lemma 1 The proof is immediate. Consider any period $t$. The agent maximizes:

$$U_t(a_t | s_n^k, H_{t-1}, \sigma) = \sum_{k \in K} \Delta u_k(x_t^k, x_{t-1}^k) - \Delta c(\tau_t, \tau_{t-1}) + EU_{t+1}(a_{t+1}|H_t, \sigma)$$

$$= \sum_{k \in K} \Delta u_k(x_t^k, x_{t-1}^k) - \Delta c(\tau_t, \tau_{t-1}) + \sum_{H_t} p(H_t | H_{t-1}, \sigma)U_{t+1}(a_{t+1}|H_t, \sigma).$$  \hspace{1cm} (2)

It is clear that for any history $H_t$ (given $H_{t-1}, \sigma$), the optimal

$$U_{t+1}(a_{t+1} | s_n^k, H_t, \sigma) = \sum_{k \in K} \Delta u_k(x_{t+1}^k, x_t^k) - \Delta c(\tau_{t+1}, \tau_t) + EU_{t+2}(a_{t+2}|H_{t+1}, \sigma)$$  \hspace{1cm} (3)

is unaltered from (2), and therefore that the maximizing choice is identical. Proceeding inductively, this holds for any history $H_{t'}$, where $t' \geq t$.

Lemma 2 By Lemma 1, dynamic consistency holds, and we can therefore analyze the problem from the ex-ante stage. Then, ex-ante, the agent maximizes the following function:

$$U_0(P_0 | \sigma) = EU_1(a_{t+1} | H_t, \sigma) = \sum_{k \in K} \Delta u_k(x_1^k, x_0^k) - \Delta c(\tau_1, \tau_0) + EU_2(a_{t+1} | H_t, \sigma)$$

$$= \sum_{t \in \{1, T\}} \sum_{k \in K} p_0(H_T | P_0, \sigma)$$ \hspace{1cm} (given $H_{t-1}$, $\sigma$).

$$= \sum_{t \in \{1, T\}} \sum_{k \in K} p_0(H_T | P_0, \sigma) \left( \left( (u_k(x_T^k) - u_k(x_{T-1}^k)) - (c(\tau_T) - c(\tau_{T-1})) \right) + \ldots + \left( (u_k(x_1^k) - u_k(x_0^k)) - (c(\tau_1) - c(\tau_0)) \right) \right)$$

$$= \sum_{t \in \{1, T\}} \sum_{k \in K} p_0(H_T | P_0, \sigma) \left( u_k(x_T^k) + u_k(x_{T-1}^k) - u_k(x_{T-1}^k) + \ldots + u_k(x_0^k) - u_k(x_0^k) \right)$$

$$+ c(\tau_T) + (c(\tau_{T-1}) - c(\tau_{T-1})) + \ldots + (c(\tau_0) - c(\tau_0))$$

which completes the proof.

A.2 Proof of Lemma 3 and Proposition 1

Fix a strategy profile of stage 0, $\sigma = (\sigma^i)_{i \in I}$, then the continuation game can be viewed as a separate and independent decision problem for each individual. Although the continuation game is, strictly speaking, of imperfect and incomplete information (as consumers do not necessarily know the state of the world, or what other consumers are choosing), because the consumers’ payoffs are independent of each others’ strategies, the subgame starting after the media firms’ strategy choices can be viewed as consisting of separate decision trees that can be solved independently from one another. Furthermore, when costs are
positive, $\nu_{SK}, \nu_{SW}, \nu_{RD} > 0$, (recall, that by assumption, $\nu_{RD} > 0$), finiteness of the number of states, the number of stories in each possible state, and the number of actions at any choice node, and the fact that all individuals are Bayes rational with a common prior over the possible states of the world, and have strictly increasing time costs $c(\cdot)$, insures that each decision tree is finite with an initial move by nature determining the state of the world. Hence it is solvable by backward induction. When costs can be zero, then consumers can in principle choose infinite sequences of, e.g., skipping stories or switching outlets (by assumption, $c(N\nu_{RD}) > \sum_{k \in K} u_k (\sum_{s^k \in S^k} \lambda(s^k))$, for any $S \in \mathcal{S}$, so that readers will always only read a finite number of stories). However, it is easy to see that once the readers have identified the state of the world, then there is no gain in further skipping and switching beyond that of reaching the stories that it is optimal to read. But this requires only finitely many skips and switches and so is solvable by backward induction, for general $0 \leq \nu_{SK} \leq \nu_{RD}, 0 \leq \nu_{SW}$. The corresponding solutions obtained (restricting to ones with no “redundant” skips or switches if necessary) yield a compact and convex set of the possible expected mass of readers, for each possible strategy profile of stage 0, for which a selection with the desired properties always exists.

This selection readily implies a choice of stories to read on any given topic and from any given outlet, for each reader, and in particular yields functions $\mu_{k,i}^\nu$. Given this, existence of a Nash equilibrium in $\Gamma$ follows immediately from the finiteness of the number of stories and of their possible rankings, as well as of the number of states, and hence of the firms’ strategies.

A.3 Proof of Proposition 3

Fix $\sigma^*$, a profile of reader-efficient rankings, and suppose that $\nu_{SW} = 0$. As profits are derived solely from attracted readership, it is not possible for a firm to deviate and attract more readers since the opponent is already offering a reader-efficient ranking (recall that, by assumption, readers, when indifferent between two outlets, stay with the bookmarked one). It is also not possible to deviate by having the bookmarked readers read more stories, since if the new ranking is not reader-efficient, it will lead to a strictly lower utility and, at $\nu_{SW} = 0$, the readers would strictly prefer to switch to an outlet with a reader-efficient ranking. Hence, no firm has an incentive to deviate. By continuity of $c(\cdot)$ and the $u_k(\cdot)$’s, it is clear that there exists a $\bar{\nu}_{SW} > 0$ that also works.

A.4 Proof of Proposition 4

Fix $\nu_{SW} \geq 0$ and consider a Nash equilibrium profile that maximizes firms’ expected profits. As we assume that there are no switches in equilibrium, we may assume without loss that the equilibrium is symmetric (see Proposition 5). Let $\sigma$ be the strategy played by the firms at $\nu_{SW}$. Suppose now that $\nu_{SW}$ increases to $\nu'_{SW}$. Then, if $\sigma$ is not an equilibrium at $\nu'_{SW}$, it is because a firm has an incentive to deviate to a strategy, say to $\sigma'$. At $\sigma'$, the firm must have the same readers (the ones bookmarked with it) but where they read more stories. (For, if a profitable deviation existed at which it attracted more readers, it would have been a valid deviation to $\sigma$ at the original $\nu_{SW}$, which violates the fact that $\sigma$ was a Nash equilibrium at $\nu_{SW}$.) Hence, if the deviation $\sigma'$ attracts the same readers, but they read more stories, this increases payoffs to the firm; since both firms retain their readers, if they both play $\sigma'$ at $\nu'_{SW}$ this constitutes a Nash equilibrium, which, moreover, gives both firms a strictly higher payoff. This shows the first part of the statement.

To see the second part, it suffices to note that if at $\sigma'$ and $\nu'_{SW}$ the readers are (also) strictly better
off, then again $\sigma'$ would also have been a valid deviation at the lower cost $\nu_{SW}$ (as it would have attracted at least as many readers but with more stories read). Hence, it cannot be that readers are also strictly better off. This completes the proof.

Finally, these two results clearly also holds relative to the skipping cost $\nu_{SK}$. To see this, simply replace skipping costs $\nu_{SK}, \nu'_{SK}$ with corresponding switching costs $\nu_{SW}, \nu'_{SW}$ in the above arguments and the same conclusions hold.

A.5 Proof of Proposition 5

Fix a game $\Gamma$ and a pure strategy profile $\sigma$ at which some readers switch outlets. We show that one of the two outlets has a strictly payoff-improving deviation. Consider the histories $H_1$ and $H_2$ of respectively a reader, say reader 1, bookmarked on outlet 1, and of a reader, say reader 2, bookmarked on outlet 2. Suppose without loss that $H_1$ is the history that leads to the most number of stories read. Consider outlet 2. We distinguish three possibilities for the histories $H_1$ and $H_2$ associated with profile $\sigma$:

Case 1: Reader 1 does not switch to outlet 2, while reader 2 switches to outlet 1 (there is at least one switch). Then outlet 2 has an obvious deviation which is to take the history $H_2$ of reader 2 and offer as a ranking the one associated to $H_2$. In this case, reader 2 will not want to switch to outlet 1, and outlet 2 can have reader 2 reading strictly more stories on its outlet (with no fewer stories read by readers from outlet 1).

Case 2: Reader 2 does not switch to outlet 1, while reader 1 switches to outlet 2. This is analogous to Case 1.

Case 3: Reader 1 switches to outlet 2 and reader 2 switches to outlet 1. In this case, outlet 2 has a deviation to offer a ranking associated with history $H_1$. It is clear that reader 1 will strictly prefer to immediately switch to outlet 2 (in the very first subperiod) and read all stories read under the original $H_1$ on outlet 2. Doing so will avoid unnecessary switching and skipping of stories and provides a utility at least as high as that of the original history $H_1$. Furthermore, reader 2 will also not want to switch to outlet 1 at any point, because this would contradict the optimality of reader 1’s choice, as both readers have the same preferences. (If reader 1 has a strict preference to switch immediately to outlet 1, then it cannot be that reader 2 with the same preference prefers to switch to outlet 1 instead of when he can stay on outlet 2.) Therefore, with this deviation, outlet 2 gets all the readers, which is clearly strictly better than what it had at $\sigma$. This shows that if $\sigma$ is a pure Nash equilibrium, then there cannot be any switches, which implies that both outlets have the same profits per reader.

Next, starting from such a pure equilibrium profile $\sigma = (\sigma_1, \sigma_2)$ with no switches, it is easy to see that both symmetric profiles $(\sigma_1, \sigma_1)$ and $(\sigma_2, \sigma_2)$ also constitute equilibrium profiles. All profiles yield the same payoffs per reader to the firms. Fix the symmetric one that gives readers the highest utility, and call it $\sigma'$. Next, remove all stories skipped and append them in the same order of occurrence right after the last story read (under $\sigma'$). The resulting ranking $\sigma''$ has the readers reading the same stories as in $\sigma'$ but now avoiding all skips. To see this, note that moving skipped stories down the ranking cannot lead to more stories being read since this would violate the property of $\sigma$ or $\sigma'$ being a Nash equilibrium (since the firms could have deviated at no cost to a ranking with more stories read; notice that stories skipped do not constitute any revenue for the firms). Moreover, because the stories skipped show up right after

\footnote{By this, we mean taking the history $H_2$ and extracting all the stories read or skipped and ranking them in the same order of occurrence as in $H_2$, and appending all other stories unread, afterwards, as they are ranked in the outlet where reader 2 stops reading. The same can be done for $H_1$.}
the stories read in the new ranking \( \sigma'' \), the reader also cannot benefit from reading fewer stories since he could also have done so earlier. Thus, \( \sigma'' \) is a pure symmetric Nash equilibrium without skips and without switches. Finally, since the same stories are read with \( \sigma'' \) as with \( \sigma' \), and readers do not have to skip stories with \( \sigma'' \), it is a weak Pareto improvement over \( \sigma' \) (and hence also over \( \sigma \)).

A.6 Proof of Proposition 6

Choose the switching cost \( v_{SW} > 0 \) as if the media firms were monopolists. Next, fix a firm and consider a strategy \( \sigma \) that maximizes the expected number of stories read by its readers in any state.

\( (a) \): To see that this can be achieved by listing the stories eventually read in increasing order, it suffices to show that, given a ranking of stories read on a given topic \( k \), say \( \sigma_{R,k} \), the reader will always still want to read those stories if a permutation is applied to the ranking that inverts the order of one pair of successive stories. More precisely, fix \( \sigma_{R,k} \) and take two successive stories from topic \( k \) that (prior to the permutation) are ranked in decreasing order of net newsworthiness and invert their order, leaving all the other stories fixed (whether within \( \sigma_{R,k} \) or not). Then the reader will still want to read the same stories in the inverted order. This follows directly from the (weak) convexity of the utility function \( u_k \) and the fact that the stories in \( \sigma_{R,k} \) already all get read under the original ranking \( \sigma \). Applying this iteratedly eventually yields a completely increasing ranking \( \hat{\sigma}_{R,k} \) of the same stories read on topic \( k \) that readers will definitely still want to read. Repeating across topics if necessary, this shows that a payoff-equivalent equilibrium profile \( \hat{\sigma} \) exists where stories within given topics are read in “reverse” order.

\( (b) \): To see that the converse is not true—that is, that for any Nash equilibrium profile where stories read are ranked with increasing order, there need not exist a Nash equilibrium profile where stories read are all ordered in decreasing order— it suffices to consider an example with two stories, namely, a newsworthy one and an irrelevant one. The reader is willing to read the newsworthy one after the irrelevant one but not vice versa. This completes the proof.

A.7 Proof of Proposition 7

We first define suspense potential in a setting when the state of the world consists of more than one topic. Let \( S = \{ (\lambda_1^A, z_1^A),..., (\lambda_{N_A}^A, z_{N_A}^A), (\lambda_1^B, z_1^B),..., (\lambda_{N_B}^B, z_{N_B}^B) \} \) and \( \tilde{S} = \{ (\tilde{\lambda}_1^A, \tilde{z}_1^A),..., (\tilde{\lambda}_{N_A}^A, \tilde{z}_{N_A}^A), (\tilde{\lambda}_1^B, \tilde{z}_1^B),..., (\tilde{\lambda}_{N_B}^B, \tilde{z}_{N_B}^B) \} \), where \( N_A, N_B \in \{ 1,...,N-1 \} \). For convenience, the indices are ordered by increasing newsworthiness within the topic, \( \lambda_k^i \leq \lambda_{N_k}^i \) and \( \lambda_k^i \leq \lambda_k^j \leq \lambda_{N_k}^i \), for \( k \in \{ A, B \} \). If \( \sum_{i=h}^{N_k} \lambda_k^i \geq \sum_{i=h}^{N_k} \tilde{\lambda}_k^i \) for each index \( h \in \{ 1,...,N_k \} \) and \( k \in \{ A, B \} \), we say that the set of stories \( S \) holds more suspense potential than \( \tilde{S} \) (written \( S \succ_{SP} \tilde{S} \)). When there is only one topic in each state (which need not be the same topic across states), define suspense potential as in the text, i.e. \( u_k(\sum_{i=h}^{N_k} \lambda_k^i) \geq u_k(\sum_{i=h}^{N_k} \tilde{\lambda}_k^i) \) for each index \( h \in \{ 1,..,N \} \). (The utility function is only required as a metric in the case of one state of the world when comparing across topics.) Note that one topic (or a selection of stories) can be the same in both states \( S \) and \( \tilde{S} \), so that we can define, in a natural way, suspense potential for only a set of stories. Note also that, while we do not require that the total newsworthiness is the same (in total or within a topic), we allow it, as would be desirable when comparing suspense potential over sets of stories that have equal total content. The statement of Proposition 7, which we prove below, is then identical to that in the main text.

**Proof** Let \( S \succ_{SP} \tilde{S} \), where \( S = \{ (\lambda_1^A, z_1^A),..., (\lambda_{N_A}^A, z_{N_A}^A), (\lambda_1^B, z_1^B),..., (\lambda_{N_B}^B, z_{N_B}^B) \} \) and \( \tilde{S} = \{ (\tilde{\lambda}_1^A, \tilde{z}_1^A),..., (\tilde{\lambda}_{N_A}^A, \tilde{z}_{N_A}^A), (\tilde{\lambda}_1^B, \tilde{z}_1^B),..., (\tilde{\lambda}_{N_B}^B, \tilde{z}_{N_B}^B) \} \). Let \( \nu_{SW} \) be prohibitively large, and consider the limit of \( \nu_{SK} = \)
\(\nu_{\text{RD}}\). The reader then never skips stories, and the choice is therefore between stopping altogether and reading further. Applying Proposition 6, suppose that with \(\bar{S}\), each (monopolist) firm chooses reverse-ranking strategy \(\bar{\sigma}\), such that within topic \(k\), the ranking is \(\{(\lambda_{jk}, z_{jk}^k), ..., (\lambda_{N_k}, z_{N_k}^k), \}\), for some \(j_k \in \{1, ..., N_k - 1\}\), where all stories up to \((\lambda_{N_k}, z_{N_k}^k)\) are then read. We show that the firm can make at least as much profit in state \(S\). Suppose that each firm follows strategy \(\sigma\), which has the same positional rankings as in \(\bar{S}\). Hence, within topic \(k\), the ranking is \(\{(\lambda_{jk}, z_{jk}^k), ..., (\lambda_{N_k}, z_{N_k}^k), \}\), for the same \(j_k\) as \(\bar{S}\). To see whether the agent will read the first story, \((\lambda_{jk}, z_{jk}^k)\), on this topic, it suffices to consider whether he is guaranteed a utility greater than zero if he keeps reading. Using Lemma 2, it suffices to consider the (degenerate) expectation, at that stage, of total ex-post utility. Note that in state \(\bar{S}\), since he is reading all stories in \(k\) between \(j_k\) and \(N_k\), it must be that utility \(u_k(\sum_{i=j_k}^{N_k} \lambda_i^k) \geq c((m_{-k} + N_k - j_k + 1)\nu_{\text{RD}})\), where \(m_{-k}\) is the number of stories already read from the other topic. Since \(S \succeq_{\text{SP}} \bar{S}\), \(u_k(\sum_{i=j_k}^{N_k} \lambda_i^k) \geq u_k(\sum_{i=j_k}^{N_k} \lambda_i^k) \geq c((m_{-k} + N_k - j_k + 1)\nu_{\text{RD}})\). Hence, at a minimum, the consumer can guarantee that he is better off by reading further than stopping. Similarly, (if \(j_k < N_k - 1\)), he reads the next story, \((\lambda_{jk+1}, z_{jk+1}^k)\), since he can guarantee utility \(u_k(\sum_{i=j_k+1}^{N_k} \lambda_i^k) \geq u_k(\sum_{i=j_k+1}^{N_k} \lambda_i^k) \geq c((m_{-k} + N_k - j_k + 2)\nu_{\text{RD}})\), where \(m_{-k}\) is the number of stories already read from the other topic (note that \(m_{-k}\) need not be the same as \(m_{-k}\), since the reader might have read additional stories from the other topic in between stories from topic \(k\)). Applying this reasoning repeatedly, we obtain that he reads at least up to \(N_k\) stories on topic \(k\), for each \(k \in \{A, B\}\). It is then straightforward to show that there are cases where firms can include at least one additional story in the ranking in \(S\) that will be read (i.e., in the optimal ranking, for a topic \(k \in \{A, B\}\), the reverse-ranking strategy is \(\{(\lambda_{j_k-1}^k, z_{j_k-1}^k), (\lambda_{j_k}^k, z_{j_k}^k), ..., (\lambda_{N_k}^k, z_{N_k}^k), \}\), in which case firms will make strictly more profit. By continuity, generically \(\nu_{\text{SK}}\) need not be at the limit of \(\nu_{\text{RD}}\) for readers not to skip. Similar reasoning, which we omit, can be applied to states of the world that contain only one topic.

### A.8 Proof of Proposition 8

By continuity of readers’ cost and utility functions, it suffices to show the case \(\nu_{\text{SW}} = 0\). Suppose that there are two outlets of which one is public and the other is a standard outlet with expected profits, as defined in Section 2.2. By assumption, the public outlet has a dominant strategy to choose a reader-efficient ranking. With \(\nu_{\text{SW}} = 0\), the other outlet can retain its bookmarked audience only if it also offers a reader-efficient ranking (it cannot take audience away from the public outlet). This constitutes a Nash equilibrium, as both firms retain their audience and cannot improve their payoff by deviating.