Time Scarcity and the Market for News

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Abstract

We develop a general theory of news media. News consumers are time constrained and perform a (possibly subconscious) optimal search, given the amount of time they possess. Their utility functions are general and allow for complementarities over the amount of information they acquire on any given topic. Media outlets are aware of consumers’ preferences and constraints, and aim to maximize readership. These outlets observe the news items of the day and decide on a ranking to provide to readers. They cannot falsify or misreport news. In the baseline model readers and outlets are unbiased and fully rational.

We then derive basic properties of equilibria on these markets for news. In particular, equilibrium rankings need not be reader-efficient. Even in competitive markets, readers may read more than they would like to; they may read stories distinct from the ones they prefer and on topics that are different from the ones they consider to be important. Next, we derive implications on diverse aspects of new and traditional media. These include a rationale for tabloid news based on complementarities in preferences, a rationale for why readers switch to certain online media platforms as a way to circumvent inefficient rankings found in traditional media, and the derivation of a positive role for public media in restoring reader-efficient standards. Finally, we relate some of our findings to recent stylized facts, and briefly discuss political economy implications of the model.

Keywords: Media economics; media competition; information search; time preference; news ranking; digital media; internet; new and traditional media; public media; tabloid news; media bias.

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1 Introduction

In spite of the virtually unlimited amount of information made available daily, the question of whether media consumers receive and consume the news they consider important remains open. There have been considerable technological improvements in the way we access, produce and transmit news, notably through the digitization of communication and the internet, yet readers remain constrained in the amount of time they allocate to news consumption.

In this paper, we take scarcity of time as a point of departure in analyzing individuals’ demand for news and media firms’ supply. Consumers have limited time and attention they can allocate to reading and discovering the news. Even if articles are free of charge, it seems neither feasible nor desirable for an individual to attempt to read every article that is available on a given day. Rather, consumers select which stories to read based on the stories’ newsworthiness and relevance of content, while taking into account their time constraints. Furthermore, readers do not have immediate access to all stories or headlines available on a given day and cannot consider the entire set. They rely on rankings provided by media outlets, who, via their editorial policies, effectively rank stories for the ease with which the readers can access them. It requires less effort to access a story on the front page of a news outlet than a story buried in the ninth page. Readers go through the ranked lists of stories and retrieve the ones they wish to read.

While decisions on news consumption may be taken at a subconscious level, consumers seem to understand that reading and viewing the news is a costly process, both through the opportunity cost of time and through the cognitive demands it places. The frequent repetition of this process arguably leads to an optimal or improved selection over articles to read, topics to focus on, and media outlets to favor or bookmark. At the same time, media outlets are aware of the preferences and time limitations faced by readers. In deciding on the order in which to present articles on their print or website editions, or on their television and radio news programs, they take into account that each story competes with a host of others for the readers’ attention.

To capture these effects, we model the market for news as follows. On the demand side, time constrained readers, independently from one another, decide to sequentially read or skip articles, to switch to other media outlets, or to stop reading the news altogether. Throughout the paper, consumers have standard preferences and specific opportunity costs of time which they can use for other activities.\(^1\) We allow for multiple topics and for reader preferences to vary across topics. Specifically, while readers may saturate as they read more of a given topic, with certain other topics they may be “caught” in the plot and become increasingly curious as they read more. For example, readers may tire quicker with news on budgetary spending than on the latest celebrity scandal. We assume, however, that readers are aware of their preferences

\(^1\)The 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.
in advance and make their choices in a dynamically consistent manner.

On the supply side, media outlets decide on a strategy for ranking the stories of the day (we also refer to this as the editorial policy). These outlets do not have any mechanism for deceit or for making an article more or less newsworthy than it actually is. They simply decide on the order in which to present the stories. In our baseline model, media outlets maximize total readership. They do not favor one topic over another, and are not biased, a priori, towards any particular topic or content. Moreover, we assume that the firms’ strategies or editorial policies are known to the readers.

Within this context we show that despite the firms’ total lack of bias, firms might not rank stories in the reader-optimal way. Equilibrium rankings may lead readers to read more stories than they would have preferred to; these stories may be distinct from the ones they would like to read and they may possibly be on different topics. This follows from the misalignment between the consumers’ preferences over the stories they wish to read and the firms’ incentives to have consumers read a maximum number of stories possible. It holds 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. Note that readers are fully aware of the firms’ preferences and editorial policy and are therefore not manipulated in any way.

The paper also provides a series of further implications on different aspects of new and traditional media. First, the presence of a freely accessible, public media firm that maximizes readers’ interests causes all firms in the market to provide the reader-optimal ranking by pressuring them to change their strategy to keep their readers, thus indirectly enforcing a reader-optimal standard. Second, by considering the possibility of topics with complementary preferences, that is, ones providing increasing returns to readers of reading more of a topic, we derive a possible rationale for tabloid news as well as “dumbed down” content. Third, while not necessarily leading to reader-optimal rankings, lower costs of skipping and switching are (weakly) welfare improving for readers and (weakly) profit decreasing for firms; this lends support to the view that technology, through the digitization of information and its accessibility on internet, can be welfare-improving to society. However, decreasing reading costs can have ambiguous effects under some conditions. Fourth, we briefly consider phenomena such as search engines, aggregators and social media. We show that they play a potentially important role in allowing readers to circumvent some of the above mentioned inefficiencies, while acknowledging that these platforms may themselves also lead to further sources of inefficiencies. Lastly, we note that the flexibility of the model allows us to compare different types of media. For instance, we consider the different use and impact of advertising on television and radio compared to online news sites.

These implications serve the added purpose of illustrating that our framework can be extended to different settings. It can be adapted to analyze different media markets with time-constrained consumers. For instance, the model can be extended to cases in which firms (or consumers) have a bias for specific topics or for specific content, to account for ideological pref-
ferences or different revenue structures. Firms can also be allowed to aggrandize or trivialize a story through their choice of headlines. Finally, the model can be placed in a political economy environment, in which the news consumption of readers translates to information acquisition over political topics.

Related Literature

This paper relates to several strands of literature. It relates naturally to the economics literature on media bias, which is surveyed in Gentzkow and Shapiro (2008), Blasco and Sobbrio (2011) and Prat and Strömberg (2013) among others. 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 agents.

In this sense, the recent literature on obfuscation and search diversion in markets with an intermediary or search platform is especially relevant to our main results on consumer-inefficient rankings. Ellison and Ellison (2009) study competition between internet retailers attracting potential customers through a dominant search engine and who adopt obfuscation strategies to soften price competition, thus frustrating consumer search. Armstrong, Vickers, and Zhou (2011), Hagiu and Jullien (2011), and De Cornière and Taylor (2012) show how an intermediary platform (e.g., a search engine) can have incentives to divert search, thereby distorting the search process away from the consumer-efficient one; 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. While taking a more specific focus, namely, one concerned with time constrained consumers and the market for news, our framework shares with the above literature a basic misalignment between the objectives of the platforms (for us the media firms) and those of the consumers as a root cause of consumer-inefficiencies; we also explicitly allow for competing media firms.\(^2\)

Also related is a large and rapidly expanding literature studying the effects of technological innovations in digital media on news and advertising markets. Dellarocas, Katona and Rand (2010), Chiou and Tucker (2011), Hong (2011), George and Hogendorn (2012), Jeon and Esfahani (2012), Jordan et al. (2012), and Palme et al. (2012), study the role of aggregators and hyperlinks as innovations in current news markets. Athey and Gans (2010), Anderson and Kind (2011), Athey, Calvano, Gans (2011), 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.\(^3\) These papers study phenomena that are outside our baseline model, but that are crucial for a complete understanding of the market for

\(^2\)For studies of communication and information overload that consider agents sending information and competing to reach audience, 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.

\(^3\)Within the broader media and communications literature, Hindman (2009) studies 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 et al. (2012) argue that the internet has not fulfilled many expectations raised; Lovink (2012) discusses media and social networks.
news. We believe that time scarcity is fundamental to the consumption and production of news, and think that the framework provided can be amplified to account for several of the phenomena studied in the above-mentioned literature.

The paper is structured as follows. Section 2 introduces the framework and shows basic properties of the model, Section 3 discusses several examples and key features, Section 4 discusses extensions of the baseline model, and Section 5 concludes. All proofs are in the Appendix.

2 Benchmark Model and Properties

We consider an environment in which the true state of the world is described by a set of stories that are exogenous and common to the media outlets. Readers derive utility from the stories they read. Given that there are costs of locating news stories, their presentation by the media matters. We focus on media outlets’ choices of ranking of the stories. We now describe the details of the basic framework used throughout.

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 $B$, unless stated otherwise. Setting $K = \{A, B\}$, we denote by $S_k \subset S$ stories that correspond to total stories on topic $k$, for $k \in K$, so that $S = \bigcup_{k \in K} S_k$. 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, or politics and entertainment. They could also be more concrete categories, such as news in the Middle East and news in Europe. We also assume that $S$ has cardinality $N$, and $S_A$ and $S_B$ have cardinality $N_A$ and $N_B = N - N_A$, respectively.

The elements of $S$ are stories $s^k_n = (\lambda^k_n, z^k_n) \in [0, 1]^2$, $n \in S_k$, $k \in K$, characterized by newsworthiness $\lambda^k_n \in [0, 1]$ and content $z^k_n \in [0, 1]$. Newsworthiness is a measure of how important and informative a story is to the reader. For most of the paper, the reader has no preference concerning the actual content $z$ of a story; he simply prefers being informed. A media outlet, on the other hand, might have a preference over the content of the stories that are read. We will consider different observational regimes concerning the content variable $z$.

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 all possible $N$-tuples of realizations of newsworthiness and content $S \subset \Omega = ([0, 1] \times [0, 1])^N$. We always assume $S$ to be finite. Let $\pi \in \Delta(S)$ be the prior on the states of the world, 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 cannot aggrandize or trivialize the newsworthiness of a story, it only has the technology to rank stories in the order in which readers view the headlines.

In the overall (Bayesian) game we consider, media outlet $i$’s strategy is a map $\sigma^i : \mathcal{S} \rightarrow \mathcal{P}_N$. As will be clear later, the uncertainty about the true state of the world is unknown to the readers, hence 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 $i$, $i \in I$, chooses $\sigma^i$ to maximize the profit function

$$
\Pi^i(\sigma^i | \sigma^{-i}) = \sum_{k \in K} (1 + \alpha^i_k) \sum_{n \in S^i_k} \mu^k_{n, i}(\sigma^i, \sigma^{-i}) + \sum_{k \in K} \beta^i_k \sum_{n \in S^i_k} \mu^k_{n, i}(\sigma^i, \sigma^{-i}) \lambda^k_{z, n} - C_F,
$$

where $\mu^k_{n, i} : (\mathcal{P}_N)^I \rightarrow [0, 1]$ is the mass of readers that outlet $i$ believes will read story $s^k_n$ from him, $\alpha^i_k \in \mathbb{R}$ is firm $i$’s preference for topic $k \in K$, and $\beta^i_k$ is $i$’s preference towards readership of content $k$. The parameter $C_F$ denotes the fixed cost of purchasing the set of stories of the day. If $\alpha^i_A < \alpha^i_B$, then the agent receives less profit from readership in topic A than topic B. This would be the case, for instance, if the revenue from selling an advertisement on a topic B page is higher than it is on topic A. If $\beta^i_k \neq 0$ for a topic $k \in K$, then the outlet has a preference over the content read by the consumers. This corresponds to a bias of the outlet towards a specific position. While we allow for the media outlets to receive more profit from a topic than another, or to be ideologically biased towards content, our main analysis will be conducted for the case in which the outlets are entirely unbiased and topic-neutral profit maximizers. That is, for most of the central results, we assume $\alpha^i_k = 0$ and $\beta^i_k = 0$ for $k \in K$ and $i \in I$. Moreover, for most of the analysis, we set $C_F = 0$, i.e. there is no cost to the outlets of purchasing the stories.

Each firm’s profit function is therefore simply a function of total readership it obtains. In later sections, we consider the impact of relaxing these assumptions.

We view a media outlet as having an editorial board that has decided on a strategy for how to display the news, given a realization of state of the world. This strategy is public and commonly known. That is, each firm knows the strategy of the other firm, as do the readers. In particular, the media outlets also know $S$ while the readers do not. The reasoning behind this modeling choice is that the editorial stance and presentation style of a newspaper is generally known to a large degree. Furthermore, while we focus on a single period and model a one-shot game, in reality readers and outlets have a repeated interaction, which reinforces the common awareness of each outlet’s editorial policy.
2.3 Readers

There is a continuum of readers, who all have the same preferences. Readers may, however, be heterogeneous concerning which website or newspaper they open first. To capture that a reader are typically constrained in the number of headlines they see in a given moment, we make the extreme assumption that a reader can only see one headline at once. By observing a headline, implies that is fully aware of certain features of the story, namely, its topic and newsworthiness. However, he does not derive utility from a story unless he chooses to read it.

When making his decision concerning whether or not to read a story, the reader takes into account the history of all stories he has read and all the headlines he has seen. That is, if he has seen the headline of a story but has chosen not to read it, he still remembers having seen the headline, and he can return to read it if he chooses. In addition, the reader takes into account his expectations over future stories, which is a function of his history and of the strategy decided by the editorial board of each newspaper. Other than reading a story, the consumer has the option to skip the story and look 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. Finally, 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 cost.

Formally, the continuum of readers is normalized to mass 1, and readers may differ about which newspaper they access first. 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. For the moment, we assume that \( M_1 \) is exogenously given. Periods at which readers make their choices are denoted \( t \in \{1, \ldots, T\} \), but these periods do 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 for which the reader takes an action to read a story (\( RD \)), to skip it (\( SK \)), to switch to a not previously accessed outlet (\( SW \)) or to stop reading altogether (\( ST \)). In this model, the reader has no incentive to return to reading any outlet once he has stopped, and therefore the decision to stop is always terminal. We normalize the agent’s continuation utility of stopping to 0. Notice that this notion of period does not imply a repeated interaction between the readers and the firms, in the sense that the firm’s choice of ordering has taken place before the reader’s decision. The firms therefore do not respond to each reader’s choice by reordering the stories.\(^4\)

A reader’s action is denoted by \( a_t \in \{RD, SK, SW, ST\} \). Actions will be defined more precisely once we define the history of the stories read and skipped by the consumer. Readers derive utility from reading articles (\( RD \)) and incur a time cost from any of the actions \( RD, SK \) and \( SW \). \( ST \) terminates the reader’s game. When choosing \( a_t \), readers know the strategies

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\(^4\)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. We return to this point in section 3.4.
of the media outlets $\sigma$, but do not observe the realization of the state of the world $S$. While the readers are familiar with the editorial policy of the outlets, they do not necessarily have sufficient information to infer the realized state of the world ex-ante. However, their histories, observations and their knowledge of the outlets’ strategies $\sigma$ allow them to update their beliefs.

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 he is observing headline $s^k_t$, $\{s^k_t, a_t\}$ is appended to his history so that $H_t = \{\{s^k_t, a_t\}, H_{t-1}\}$. 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 determines 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; given strategy $\sigma^i = (\sigma^i_1, \ldots, \sigma^i_N)$, if at time $t$ he reads story $\sigma^i_n$, then the next observes story is $\sigma^i_{n+1}$, where $\sigma^i_n = \emptyset$ for $n > N$, $i \in I$;

**SK** when a reader skips to another story he observes $\sigma^i_{n+1}$; 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 $\sigma^i_{n+1}$;

**SW** when a reader switches from outlet $i$ to a so far unopened outlet $-i$ he observes the first headline of outlet $-i$, $\sigma^{-i}_1$.

Given this, the actions $RD$, $SW$, and $ST$ are all 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 $SK$, on the other hand, needs further specification. We assume that the reader can choose to skip forward, which means 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, 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 total amount of newsworthiness $\lambda^k$ consumed on this topic, in all periods up to and including period $t$. This total amount is expressed as

$$x^k_t = \begin{cases} x^k_{t-1} + \lambda(s^k_t) & \text{if } a_t = RD \\ x^k_t & \text{otherwise} \end{cases}$$
where \( x^0_0 = 0 \).

We are now in position to define the maximization problem of the reader. At any period \( t \in \{1, \ldots, T\} \), given observed headline \( s^k_n \) and history \( H_{t-1} \), the agent chooses action \( a_t \in \{RD, SK, SW, ST\} \) that maximizes the expected utility function

\[
U_t(a_t|s^k_n, H_{t-1}, \sigma) = \sum_{k \in K} \Delta u_k(x^k_t, x^k_{t-1}) - \Delta c(\tau_t, \tau_{t-1}) + EU_{t+1} (a_{t+1}|H_t, \sigma)
\]

where \( \Delta u_k(x^k_t, x^k_{t-1}) = u_k(x^k_t) - u_k(x^k_{t-1}) \) and \( \Delta c(\tau_t, \tau_{t-1}) = c(\tau_t) - c(\tau_{t-1}) \).

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 stories on topic \( k \) increases the utility of the additional stories read. If instead, \( u''_k(\cdot) < 0 \), then the agent has diminishing marginal utility of reading additional stories on a topic. At the moment, we assume that \( u''_A(\cdot) = 0 \), and will consider different assumptions concerning \( u''_B(\cdot) \).

If the agent chooses to stop at any point \( (a_t = ST) \) then he cannot return to reading in the future, so that his expected utility from that period onwards is \( EU_t (s^k_n, a_t|H_{t-1}, \sigma) = 0 \). We assume \( c'(\cdot) > 0 \) and \( c''(\cdot) > 0 \). 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. 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, as the order in which stories are presented would not matter. To guarantee that readers will not choose to read all stories in \( S \), we assume the following: \( c(0) = u_k(0) = 0 \) and \( c'(0) < u'_k(0) \) for \( k \in K \), and \( c(N\nu_{RD}) > \sum_{k \in K} u_K (\sum_{s^k \in S} \lambda(s^k)) \), for any \( S \in S \). In 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.

### 2.4 Properties of Reader’s Preferences

Before describing the timing of the game, we first explain the intuition of the reader’s preferences. There are different, and equivalent, interpretations that apply to the utility function described above. The first is the notion that in every period \( t \), the agent does a marginal benefit-marginal cost analysis. Before deciding whether to reading 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 to the marginal cost of the additional time it would take to read this story, \( \Delta u_k(x^k_t, x^k_{t-1}) \). This is exactly the same procedure as would be used in maximizing a utility function, although this method is not always thought of being
sequential. The two are exactly equivalent, however. First, we 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.** 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 read an article on a given topic $k$ increases his marginal utility of reading more stories on this topic $u'^k_k > 0$, he is fully aware of this beforehand. He does not become “addicted” in a way that he had not anticipated, and read more than he had intended. 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. It is easy to show that the agent’s preferences can be represented as follows.

**Lemma 2.** Let the agent’s ex-ante plan of action be denoted $P_0$, 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 plan of action which 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 plan of action which 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 $u'^k_k > 0$, 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 orders $(\sigma^i(S))_{i \in I}$ for every state of the world $S \in \mathcal{S}$. These strategies are observed by all parties.

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

**Stage 2** In period 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. Period by period they update their beliefs about the state of the world and choose an action $a_t$ for every period $t \in \{1, \ldots, T\}$. 


Stage 3 Final payoffs are realized.

This leads to an extensive form game of incomplete and imperfect information $\Gamma_{\text{ext}}$ between media outlets and readers.

Given media outlets’ strategies in stage 0 and given that consumers are individually negligible, consumers’ expected demand is always well-specified and easy to derive.

Lemma 3. Let $\sigma = (\sigma^i)_{i \in I}$ be a strategy profile in stage 0, then there exists a function $\mu_{n,i}^k$ that associates to each such profile the expected mass of readers going to an outlet $i$ on given story $s_{n}^k$ of given topic $k$.

This allows us to reduce the overall extensive form game $\Gamma_{\text{ext}}$ to a simultaneous game of complete information $\Gamma$ between just the media outlets, which we refer to as the reduced game.\footnote{Throughout the paper we assume that whenever indifferent between two plans (or continuation plans) of action, the consumer always chooses in favor of 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 $\mu_{n,i}^k$ and hence the reduced game $\Gamma$ well-defined.}

Proposition 1. The reduced game $\Gamma$ always has a Nash equilibrium, and the extensive form game $\Gamma_{\text{ext}}$ always has a perfect Bayesian equilibrium.

Notice that, generally speaking, existence is guaranteed in mixed strategies. This is indeed the general form of the equilibria that can be guaranteed to exist in our game. Nonetheless, we take the view that depending on the degree of discreteness of the payoffs deriving from the overall game, that pure strategy equilibria may indeed exist in many or most cases. Reny (1999) provides a set of sufficient conditions for the existence of pure strategy and also symmetric pure strategy equilibria. Although not always necessary, we will typically assume that a pure strategy Nash equilibrium exists. Finally, when confronted with multiple equilibria, we support selecting in favor of the one(s) generating the largest profits to the media outlets.

2.6 Basic Equilibrium Properties

In this section we explore the role of small switching or skipping costs in obtaining reader-efficient rankings. We also provide conditions under which skips and switches do not actually occur in equilibrium.

2.6.1 Efficient Benchmark and Competition

The basic efficiency benchmark in our framework occurs when skipping costs are arbitrarily small. In this case the readers can simply skim all headlines before deciding which stories to
actually read, in which case the loss in welfare to any reader is of the order no more than $2N \cdot \nu_{SK}$. To see this, consider the strategy of skipping all the stories to see the headline, then return to the beginning and read stories in the reader-efficient list and skip the others. Because the reader’s utility does not depend on the order in which he reads the stories, this yields a reader-efficient utility level.

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

Reducing the skipping cost then always results in a welfare improvement for readers in terms of bounding the welfare losses. Moreover, all equilibria are reader-efficient if in the limit skipping costs are zero. Since, in our basic game $\Gamma$, the media outlets do not benefit from having readers skip stories on their outlet, this readily implies the following efficiency benchmark.

**Corollary 1.** For any given game $\Gamma$, there exists a $\tilde{\nu}_{SK} > 0$ such that for any $\nu_{SK} < \tilde{\nu}_{SK}$ 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.

This suggests that a medium like television or radio where it is relatively expensive (if not impossible) to skip can lead to potentially larger inefficiencies than with print newspapers or, depending on the interface, online newspapers. Notice that the existence of the efficient benchmark for small skipping costs does not depend on the size of the switching cost, or, in other words, on the degree of competition between the two outlets. In the limit when $\nu_{SK} = 0$, any ranking is reader-efficient because readers can skip all stories at no cost, learn the state of the world, then proceed to read the utility maximizing stories. This is not the case with switching costs, as we will discuss. Nonetheless, the following result guarantees the existence of a reader-efficient equilibrium at zero switching costs.

**Proposition 3.** For any given game $\Gamma$, there exists $\tilde{\nu}_{SW} > 0$ such that, for any $\nu_{SW} < \tilde{\nu}_{SW}$, there exists a reader-efficient Nash equilibrium of $\Gamma$.

While a reader-efficient equilibrium exists for low switching cost, it is generally not the case that all Nash equilibria are reader-efficient, including at the limit where $\nu_{SW} = 0$. This is illustrated in the examples in Section 3. Nonetheless, it is the case that lower switching are typically beneficial for readers as the following proposition shows.

**Proposition 4.** For any given game $\Gamma$, firms’ profits at the profit-maximizing Nash equilibria are weakly increasing in the switching cost $\nu_{SW}$, and readers’ utilities are weakly decreasing.

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 reaching the reader-efficient level when $\nu_{SW} = 0$. This is consistent with the tendency of media firms to want to "capture" their audiences in various ways in order to increase $\nu_{SW}$, and indirectly profits.

### 2.6.2 Coordination Benchmark

The next result shows that there are no switches in equilibrium with a homogeneous audience. Moreover, assuming that the selected equilibria are those that favor the firms, equilibrium rankings coincide across firms and avoid skips.

**Proposition 5.** 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 there are no switches involved. 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.

This implies that with homogeneous consumers and no uncertainty about the state of nature, in equilibrium, media firms exhibit the same rankings, and readers do not skip stories nor switch outlet. This holds even for small skipping and switching costs and so provides a first possible rationale for why news segments may be very similar.

### 3 Technology, Competition, and Efficiency: Some Key Features

We now show some central implications of the model by means of a simple example. This example exhibits features of equilibrium rankings that are potentially undesirable for readers. Even with competition and without uncertainty in the state of the world, competing media outlets may rank stories such that readers read “too many” stories, on the “wrong” topic. In addition, the stories may be ranked in the “reverse” order starting with the least rather than the most important ones. Next, we highlight the role of complementary preferences and the “story endowment effect”, and finally consider uncertainty and heterogeneous readers.

Throughout most of this section, we maintain a setup with two topics and two unbiased media firms with no fixed cost: $K = \{A, B\}$, $I = \{1, 2\}$, $\alpha^i_k = 0$, $\beta^i_k = 0$ and $C^i_F = 0$, for $k \in K$, $i \in I$.

#### 3.1 A Robust Example with Reader-Inefficient Features

Readers are homogenous and all have utility functions $u_A(x) = x$ and $u_B(x) = 2x^2$ over topics $A$ and $B$, respectively, and their time cost function is given by $c(\tau) = 4\tau^3$. Readers thus have linear preferences for topic $A$, as may be the case with “economic news”, or “international news”, while they have convex preferences for topic $B$, as may be the case with “celebrity scandals”: the more a consumer reads, the more he is interested in the topic and the more he wants to read.
from it. While we could allow for another topic in which readers have concave preferences, we maintain the linear and convex case for simplicity.

Suppose that the only state of the world is the following,

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

meaning that there are five stories of which two are on topic $A$ with levels of newsworthiness 1 and 0.5, and three on topic $B$ with levels of newsworthiness 0.456, 0.455, and 0.454. Recall that levels of newsworthiness enter different utility functions, depending on the topic, and are therefore not always comparable across topics. Recall also that the content of the story itself is not relevant in the benchmark case in which firms are unbiased and in which readers’ preferences only depend on newsworthiness.

### 3.1.1 Monopoly Media: Too Many Stories and on the Wrong Topic

Consider first the case of a monopoly outlet, which corresponds to a switching cost $\nu_{SW}$ that is sufficiently large. Assume also that the skipping and reading costs are respectively $\nu_{RD} = 0.3$ and $\nu_{SK} = 0.05$. Then, a reader-efficient ranking consists of any ordering that places story $(1, z_1^A)$ on topic $A$ first, for instance,

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

The reader would then only read story $(1, z_1^A)$, thereby obtaining a utility of 0.892. This is not an equilibrium. Instead, the firms rank the stories in the following order,$^6$

$$\hat{\sigma} = \{(0.454, z_1^B), (0.455, z_2^B), (0.456, z_3^B), (0.5, z_1^A), (1, z_2^A)\}.$$  

Instead of reading his preferred story $(1, z_1^A)$, the consumer will choose not to skip any stories, read the first three stories in the ranking $\{(0.454, z_1^B), (0.455, z_2^B), (0.456, z_3^B)\}$, and then stop, obtaining utility 0.810. 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.

Two central features are contained in this example: (i) the consumer reads too many stories – here he reads three stories instead of one; and (ii) the consumer reads the wrong stories – here all the stories read are drawn from the “wrong” topic $B$ instead of $A$. The result holds with full temporal-consistency, without any manipulation on the part of the media, with no external bias, and without uncertainty.

$^6$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.
3.1.2 Perfect Competition: Persistence of the Inefficiencies

Consider now the case of “perfect competition”, or, more precisely, $\nu_{SW} = 0$. It is easy to see that the above inefficiencies remain. Suppose 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. Neither firm has incentive to deviate. This is because a firm can only profitably deviate by capturing the other firm’s market share, which here it can only do by having the consumer read exactly one article, namely story $(1, z_{A1}^A)$. 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, $M_1 < 2/3$). Therefore, since $M_1 = M_2 = 1/2 \in (1/3, 2/3)$, neither firm wants to deviate from $\hat{\sigma}$.

The result does not hinge on there being two firms, or on the range $(1/3, 2/3)$ of the measure of readers. A similar equilibrium can be sustained with more firms, or for a larger range, with the inclusion of more stories. This equilibrium yields firms the highest payoffs and is therefore our selected equilibrium. In particular, it yields firms higher payoffs than the reader-efficient one, which also exists by Proposition 3.

This suggests that even with competing outlets, readers may end up seeing or reading too many stories and not necessarily the ones they would like to see. Notice that the degree of this inefficiency to consumers depends in an important way on the skipping cost, as follows from Proposition 2.

3.1.3 Non-Welfare-Enhancing Technology: Reducing Reading Costs

The reading cost $\nu_{RD}$ can be seen as reflecting several aspects of reading a given article. These include the technological sophistication of the layout and how easy it is to read online news; it can also reflect the size of the screen of the device used to read the news (desktop, laptop, tablet, smart phone and so forth). We show here that the reading cost matters for the equilibrium and that increasing it may actually make the reader better off.

Let the switching cost be $\nu_{SW} = 0.07$, and let the measures of reader for firm 1 and firm 2 be $M_1 = 0.51$ and $M_2 = 0.49$, respectively. The equilibrium from the previous cases exists: $\sigma_1 = \sigma_2 = \hat{\sigma}$. Moreover, as in the monopoly case, the reader will read all of topic B in all equilibria. That is, there is no equilibrium in which firms provide they provide a reader-optimal order. To see this, suppose that both firms provide the reader-optimal order in which story $(1, z_{A1}^A)$ is ranked first. Then, firm 1 will deviate to

$$\hat{\sigma} = \{(0.454, z_{B1}^B), (0.455, z_{B2}^B), (0.456, z_{B3}^B), (1, z_{A1}^A), (0.5, z_{A2}^A)\},$$

knowing that its bookmarked readers will not switch to firm 2. By staying with firm 1 and reading the first three stories, a reader obtains utility 0.810, while switching firm yields 0.797.

\footnote{Using non-equal bookmark measures serves only for clarity of exposition.}
Now, suppose that the reading cost increases to $\nu_{RD} = 0.31$. It might appear that it cannot be that an increase in costs makes the reader strictly better off, but this is precisely what occurs in this case. With the increased reading cost, the only equilibria are the ones in which both outlets choose a reader-efficient ranking. To see this, note first that it is no longer possible for either firm to get readers to read more than two stories from topic $B$. If they read all three, then they obtain utility 0.509, but reading any two stories leads to utility greater than 0.699.

This implies that there is no equilibrium in which either firm can “force” its readers to read two stories on topic $B$, as there would always be an incentive for both firms to deviate. To see this, suppose both firms 1 and firm 2 are providing the best two stories of topic $B$. A reader then obtains utility 0.707. But if firm 1 deviates and ranks story $(1, z^A_1)$ of topic $A$ first, then the reader switches, as he can obtain utility 0.781. If $M_1 < 0.5$, then firm 1 deviates, as it now gets $1 > 2 \cdot M_1$ of its stories read. If instead, $M_1 > 0.5$, then firm 2 deviates, as it gets $1 > 2 \cdot (1 - M_1)$ stories read. Therefore, in all equilibria, readers read only story $(1, z^A_1)$ of topic $A$, which is ordered first by both firms. In this equilibrium, readers’ utility is 0.881. This utility is higher than the highest utility obtained with a lower reading cost.

3.1.4 Complementarities, Story Endowment, and Tabloid News

Demand for news on a given day often depends on the stories consumed on previous days. This is easily taken 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 does not include any story read prior to $t = 1$ and thus set $x_0 = 0$. But it is no problem to allow for $H_0 \neq \emptyset$ and $x_0 > 0$.

Suppose then that agents are “endowed” with a story, at no time cost. For instance, an individual who is following 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 it is in topic $B$, exhibiting complementary preferences, 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 readers’ 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 best interest of a candidate to use an otherwise unrelated event, or to provide a relatively entertaining, but politically irrelevant, minor “gaffe,” to shift the reader attention away from a deeper, politically more problematic story about his actual policies. At the same time, this is suggestive of the style and type of stories covered by “tabloid” newspapers or news sites (e.g., The Sun, Daily Mirror in the UK). The complementarity of preference aspect seems very pertinent to the gossip and sensationalist stories typically associated with this type of journalism.
3.2 Ranking Benchmarks

Next we analyze the ranking of stories covered in terms of order of newsworthiness. While one often sees the most newsworthy stories ranked at the top, it is also not unusual in certain circumstances to see stories ordered by *increasing* rather than decreasing newsworthiness. For example, radio or television news stations often leave the main story to the very end of a news segment after having announced it at the beginning 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 less relevant stories. Formally, the following “reverse-order” result for stories read holds.

**Proposition 6.** Let $\Gamma$ be a game with one state of the world and large switching cost $\nu_{SW} > \bar{\nu}_{SW}$, for some $\bar{\nu}_{SW} > 0$. Suppose readers have linear preferences. Then:

(a) For any Nash equilibrium $\sigma$ of $\Gamma$ there exists a payoff equivalent Nash equilibrium where stories read are ranked by increasing order of net newsworthiness with the first story read being the least important story read.

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

While this “reverse order” result need not hold universally (e.g., if there is uncertainty about the true state of the world or if there is strong competition between outlets through sufficiently $\nu_{SW}$), it is nonetheless representative of practically relevant cases. For example, suppose that the “typical” state of the world has one important story and a number of other less relevant ones. If the less important stories are presented first, he may read them while expecting the main one further in the ranking. If, however, he is presented with the main story first, he may decide not to sit through the other less relevant ones. This effect may be heightened with media such as television or radio, where the skipping cost is especially high. We return to a comparison of media in the next section.

Another implication of the last proposition concerns the ranking across topics. It shows that stories need not necessarily be grouped together in the ranking by topic, and that it may be optimal, in some cases, to “unbundle” the stories. That is, different topics may appear one after the other, with readers possibly switching between topics while reading. This is not unusual in news, particularly online news. This last implication may be dampened by a possible consumer preference to read stories within topics together.

3.3 Uncertainty over the States of the World

We now relax the assumption that there is just one state of the world. In doing so, we show how uncertainty can be beneficial to firms, as it provides them with an additional tool for attracting
more readership. In particular, firms can keep readers in suspense in order to get them to read stories that they otherwise would not read, in the hope of eventually reading (or viewing) an important story to come ahead.

Consider the same preferences as in Section 3.1, $u_A(x) = x$, $u_B(x) = 2x^2$, with $\nu_{RD} = 0.3$, prohibitively high switching cost $\nu_{ST}$, and a high skipping cost $\nu_{SK}$. Assume that there are two states of the world, $S = \{S_1, S_2\}$, where the states

$$S_1 = \{(2, z_1^A), (0.5, z_2^A), (0.8, z_1^B), (0.2, z_2^B), (0.2, z_3^B)\}$$

$$S_2 = \{(2, z_1^A), (0.5, z_2^A), (2, z_1^B), (0.2, z_2^B), (0.2, z_3^B)\},$$

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

$$\sigma^*(S) = \begin{cases} 
\{(2, z_1^A), (0.5, z_2^A), (0.8, z_1^B), (0.2, z_2^B), (0.2, z_3^B)\} & \text{if } S = S_1 \\
\{(2, z_1^B), (0.2, z_2^B), (0.2, z_3^B), (2, z_1^A), (0.5, z_2^A)\} & \text{if } S = S_2,
\end{cases}$$

according to which a consumer reads $(2, z_1^A)$ in state 1 and $(2, z_1^B), (0.2, z_2^B)$ in state 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. But with uncertainty the firms can in fact make the consumers read more in both states of the world. Suppose that each firm ranks the stories according to the following strategy,

$$\bar{\sigma}(S) = \begin{cases} 
\{(0.2, z_2^B), (0.2, z_3^B), (0.8, z_1^B), (2, z_1^A), (0.5, z_2^A)\} & \text{if } S = S_1 \\
\{(0.2, z_2^B), (0.2, z_3^B), (2, z_1^B), (2, z_1^A), (0.5, z_2^A)\} & \text{if } S = S_2,
\end{cases}$$

In equilibrium, the reader only considers two actions that are not strictly dominated. His first option is (i) to read all three stories, regardless of the state and his second option is (ii) not to read any story at all.\(^8\) Recall that by Lemma 1, it suffices to consider the ex-ante stage, since the agent is temporally consistent and does not deviate in future periods from his plan of action. Furthermore, by Lemma 2, the agent maximizes expected utility $E[u_A(R^A) + u_B(R^B) - c(\tau)]$. In case (i), his final history is:

$$H_T^{(i)}(S) = \begin{cases} 
\{RD(0.2, z_1^B), RD(0.2, z_2^B), RD(0.8, z_2^B), ST\} & \text{if } S = S_1 \\
\{RD(0.2, z_1^B), RD(0.2, z_2^B), RD(2, z_2^B), ST\} & \text{if } S = S_2,
\end{cases}$$

with expected utility $U^{(i)} = pu_B(1.2) + (1 - p)u_B(2.4) - c(3\nu_{RD})$. In case (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 $\hat{p}$ such that, for $p < \hat{p}$, the reader will read all three stories of topic $B$ in both states.

\(^8\)Not reading any story yields zero utility, which is preferred, in state 1, to reading the stories in the given the order in which they are presented. Recall that we are assuming high skipping cost (i.e. $\nu_{SK} \rightarrow \nu_{RD}$).
of the world. 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 a single state of the world, then a similar, and perhaps more pronounced, implication holds with uncertainty as well.\footnote{This is consistent with results from the empirical search literature, (e.g., Jeziorski and Segal, 2012).} Note once more that the result does not rely on any manipulation of the readers beliefs; they are rational, temporally consistent and fully aware of the firms’ choices.

### 3.4 Heterogeneous Readers and Targeting

Targeting, or the possibility of using profile data of consumers to deliver individualized or “targeted” content (or advertising) to consumers, is one of the important innovations of internet, separating it from traditional media (e.g., Bergemann and Bonatti, 2011, Athey et al., 2012, Levin, 2013; but also Pariser, 2011). Although not yet fully developed, it can be viewed as a justification for our assumption of homogeneous consumers. In this section, we show that if consumers differ in their cost functions, then the inability to target can lead to anti-coordination in the headlines; whereas the ability to target can make each consumer type worse off.

#### 3.4.1 Anti-Coordination in the Headlines

In our examples discussed so far, profit-maximizing outlets choose to fully coordinate on the ranking of stories in equilibrium, as a consequence of firm symmetry and consumer homogeneity. Extending the model to agents that are heterogeneous in some dimension could lead to anti-coordination and specialization. This applies especially when news outlets have limited ability to target their news coverage to individual readers. An example of heterogeneity pertinent to our analysis is when readers have different time costs or switching costs. (For instance, readers with busy work schedules might face relatively tighter time constraints and higher time costs, while young and technologically savvy readers might face relatively lower switching costs.)

Consider the case with heterogeneous switching costs.\footnote{The same example goes through with heterogeneous time costs $c_1(\cdot) \gg c_2(\cdot)$ or $c'_1(\cdot) \gg c'_2(\cdot)$.} Suppose firm 1 has, among others, two types of agents, those with a sufficiently large switching cost and those with an arbitrarily low one, i.e., $\nu_{SW,1} \gg \nu_{SW,2}$, where the respective measures, $M_{1,1}$ and $M_{1,2}$, satisfy $M_{1,1} > 1/2$ and $M_{1,2} = 1/3$; the remaining agents’ costs can be arbitrarily chosen. It is easy to see that in this case, firm 1 has incentive to keep strategy $\hat{\sigma}$, while firm 2 will play the consumer-welfare maximizing strategy $\sigma^*$. A mass $M_{1,1}$ of readers will read the three stories on topic B offered by firm 2, while $1 - M_{1,1}$ will read only the first story on topic A, offered by firm 1.

#### 3.4.2 Non-Welfare Enhancing Technology: Targeting

The ability of media firms to track and hence target their audience seems to be increasing steadily (e.g., Athey and Gans, 2010, and Bergemann and Bonatti, 2011). Suppose 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 in many cases 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 of Section 3.1, but with heterogeneity in preferences. Utility $u_1^A(x) = u_2^A(x) = x$ for both, but type 1 has utility $u_1^B(x) = 2x^2$ and $u_1^C(x) = 0$, while type 2 has utility $u_2^B(x) = 0$ and $u_2^C(x) = 2x^2$. They have identical costs of time $c_1(\tau) = c_2(\tau) = 4\tau^3$, and identical reading costs $\nu_1^{RD} = \nu_2^{RD} = 0.3$. Assume prohibitively high skipping and switching cost $\nu_1^{SK} = \nu_2^{SK}$ and $\nu_1^{SW} = \nu_2^{SW}$. There is one state of the world

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

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

When targeting is not possible, the firm places stories $(1, z_1^A), (0.8, z_2^A)$ first, as it will lose readers of either type 1 or type 2 if it places either topic B or C first. All consumers then receive their preferred ranking. However, when targeting is possible, the media firm places $(0.456, z_1^B), (0.455, z_1^B), (0.454, z_2^B)$ first for type 1 readers and $(0.456, z_1^C), (0.455, z_1^C), (0.454, z_2^C)$ for type 2 readers. Both types read the first three stories. Neither type of reader has an incentive to “pretend” to be the other type, and both reader types are strictly worse off with targeting. This example illustrates that targeting may also have a negative impact on readers, besides the well known, welfare-improving aspects, associated to better tailoring to the audience.

## 4 Extensions

We now discuss important aspects of the media that can naturally be addressed by building on our basic model. While we do not conduct a complete analysis of these extensions, our aim is to illustrate the flexibility of our framework.

### 4.1 Advertising Segments

Among the main impacts of advertising on consumers are in the time costs that it imposes, and on the screen-space it takes from the stories. Our framework can be extended to incorporate these
factors.\footnote{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.} For instance, we can introduce commercials that are in essence stories with a reading cost attached, but with near-zero newsworthiness. We can further assume that consumers are obliged to “see” the commercial before advancing through the website, as is often the case with online media. 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 either case, advertising can be interpreted as creating a disutility in the form of an additional time cost of seeing 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 different reporting and advertising strategies might be optimal. 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 an additional cost of $\nu_{AD}$. A media firm obtains profits $r_{AD}$, where $r_{AD} \geq 0$, from a consumer who views an advertising segment. In this extended game, media outlets must choose where in the website, if any, to endow with an unavoidable advertisement segment. They face a tradeoff between the increased profits from the advertisement and the possible decrease in news consumption by the reader due to the additional cost incurred.\footnote{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 read would be $1 + r_{AD}'$.}

As in the examples above, suppose 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 $c_1(\tau) = d\tau^3$, where parameter $d > 0$, and assume for the moment that $d = 3$. Let $\nu_{RD} = 0.3$, $\nu_{SK} = 0.05$, and $\nu_{AD} = 0.09$. Assume that $\nu_{SW}$ is sufficiently large so that each firm is effectively a monopoly. Let $r_{AD} = 1.1$, so that the firm strictly prefers having the reader view one more commercial than 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 receive utility 6.82. 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 advertising segments. The consumer now reads three stories and views two adver-
tisements. 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 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 two stories only. Intuitively, the reader has less incentive to stay on the website as he reads, as there are less stories that he wishes to read in the future.

But suppose instead that the only state of the world is $\tilde{S} = \{(0.6, z_{B1}^P), (0.6, z_{B2}^P), (0.6, z_{B3}^P), (0.6, z_{B4}^P)\}$. It is made of only complementary stories, i.e. stories of topic B. Without advertising, the consumer reads four stories, as in state $S$. He receives utility 6.34, which is less than it would have been in state $S$ when there is no advertising. Nevertheless, the firm can still make more advertising revenue in state $\tilde{S}$. The firm’s strategy is now $\tilde{\sigma} = \{AD, (0.6, z_{B1}^P), AD, (0.6, z_{B2}^P), AD, (0.6, z_{B3}^P), (0.6, z_{B4}^P)\}$, 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. With complementarities, the firm can essentially employ suspense to keep readers through an advertisement to see the end of a story. This result is consistent with well-known empirical observations.

The firm therefore 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 had a choice between stories from both topics, it would prefer to display stories of 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 parameter $d$ to change. As $d$ increases, the firm places less advertisements. For instance, if $d = 4$, then the firm’s strategy in state of the world $\tilde{S}$ is $\tilde{\sigma}' = \{AD, (0.6, z_{B1}^P), AD, (0.6, z_{B2}^P), AD, (0.6, z_{B3}^P), (0.6, z_{B4}^P)\}$. The consumer then reads three stories and views two advertisements. The result that the reader views less advertisements as his time constraint increases is robust (up to integer problems).

4.2 Public Media

The value of public media has been a subject of debate over the last years. Recently, the topic has garnered extensive attention during the US presidential campaign, culminating in the presidential candidate Mitt Romney’s well-publicized comment during the first 2012 United States presidential debate, in which he expressed his intentions to stop government funding of the public broadcasting television network PBS (Public Broadcasting Service), if elected.\(^{13}\)

We therefore consider the effect of the public media within the context of our model. We add

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\(^{13}\)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. I actually like you too [to debate moderator Jim Lehrer, anchor at PBS NewsHour]. But I’m not going to – I’m not going to keep on spending money on things to borrow money from China to pay for.”
a public media firm, and assume that maximizes the utility of the average viewer’s. In our present application with homogeneous readers, it is straightforward to show that the public outlet always directly chooses the reader-efficient ranking. More strikingly, however, when a public firm is present in the market with other firms and with low reader switching costs, all equilibria are reader-efficient.\footnote{Recall from Proposition 3 that the existence of a reader-efficient Nash equilibrium is guaranteed for sufficiently small switching cost.}

**Proposition 7.** For any given game $\Gamma$, where one of the media outlets is a public one, there exists a $\bar{\nu}_{SW} > 0$ such that for any $\nu_{SW} < \bar{\nu}_{SW}$ there exists a unique Nash equilibrium of $\Gamma$ that 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 are from other outlets. In fact, no consumer switches outlet, even in the case of low switching costs. Rather, the presence of the public firm changes the equilibrium itself; all firms choose to provide a reader-efficient ranking. The public media firm effectively sets a standard that other outlets must adhere to. Our model therefore provides a mechanism through which the existence of the public media can in itself have important consequences on the media market.

### 4.3 Prices and Access Fees

We briefly consider the effect of allowing media firms to charge a price for access to their websites. For simplicity, we assume that each firm $i \in I$ can charge a fixed unit price, $p^i \geq 0$, in stage 0 of the game $\Gamma_{ext}$. We illustrate the impact of price competition by means of the example of Section 3.1. We assume that the expected utility function is as before, except that the price $p^i$ is subtracted in any given period $t$ when the reader accesses firm $i$’s website for the first time.

Consider first in which the reader has prohibitively high reading costs, so that each firm is effectively a monopoly. The monopoly faces a trade-off from giving a ranking closer to the one preferred by the reader and charging a higher price, and losing revenue from the diminished number of stories read. In this specific example, suppose that the profit function is such that optimal strategy is still to choose the ranking

$$\hat{\sigma} = \{(0.454, z^B_1), (0.455, z^B_2), (0.456, z^B_3), (0.5, z^A_1), (1, z^A_2)\},$$

This comment has been widely covered and discussed; for instance, it is first on google’s list of “trending” US political gaffes of 2012 (see www.google.com/zeitgeist/2012/#united-states/news/political-gaffes), and has led to a quarter million “Tweets” on Twitter (see blog.twitter.com/2012/10/dispatch-from-denver-debate.html).

At the same time, with per capita public spending on the media at less than $4 per year, the US has one of the lowest such rates among advanced democracies, where corresponding figures are substantially higher (e.g., Benson and Powers, 2011, in a comparative study with further 14 OECD countries, finds figures of between $30 and $134 per capita per year ).
(see Section 3.1). It then charges a fee $\hat{p} = 0.810 = U_0(\hat{P}|\hat{\sigma})$ to access the website, where $U_0(\hat{P}|\hat{\sigma})$ corresponds to the consumer’s utility of reading the three stories on topic $B$. This allows the firm to completely appropriate the consumer rent.

In the case of competition with a switching cost of $\nu_{SW} \geq 0$, in the profit-maximizing equilibrium, firms choose the ranking $\hat{\sigma}$ and a fee of $\hat{p}^1 = \hat{p}^2 = \min\{U_0(\hat{P}|\hat{\sigma}), \nu_{SW}\}$ so that final utility is $[U_0(\hat{P}|\hat{\sigma}) - \nu_{SW}]^+$, where $[x]^+ = \max\{x, 0\}$. The firms can appropriate more consumer rent the higher the switching cost is. Note that when the switching cost goes to zero, the prices set by the firms also goes to zero in all equilibria. In the limit in which there is no switching cost, the price is exactly zero in all equilibria, including the reader inefficient equilibrium of the example, which remains an equilibrium. In other words, while prices go to zero as switching cost go to zero, the reader inefficient equilibrium still exists in a setting with competition in price. This result is general. Furthermore, Proposition 7 of the previous section extends to a setting with prices as well. If one of the media outlets is public and if switching cost is zero, then the reader-efficient ranking $\sigma^*$ is again chosen by all outlets, together with a zero fee.

### 4.4 Comparing Different Medium Types

The essential feature of our model is that consumers of media follow an order when they access news stories, and that this order can be impacted by the firms. This feature is shared by most standard media types, including television, radio, print newspapers, magazines, and digital news consumed through tablets or smart phones. Our framework can therefore be interpreted, or adapted and applied, accordingly. In particular, reading, skipping and switching costs can be adjusted to suit specific media formats.

While we have shown in Proposition 5 that equilibria typically avoid both skips and switches in the case of homogeneous readers, this does not imply that these costs are irrelevant. As is evident from the examples, the magnitude of the corresponding costs is crucial in determining the equilibrium rankings. Furthermore, the story rankings chosen by firms also depend on the consumers’ time constraints, which may also vary across media types. Therefore, when analyzing the equilibrium rankings across the 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.

Specifically, we sketch one important comparison, leaving a more complete a detailed analysis for future research. Consider the case of (live) broadcast television and radio. In both cases, while the switching cost may be relatively low, the skipping cost 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. 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 new consumption (see, e.g., Pew Research Center, 2012).
Based on our discussion in Section 4.1, we also conjecture that there may be more advertisements for television and radio than with media where skipping costs are smaller.\textsuperscript{15} 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. In fact, our results suggest that this form of regulation should be particularly important for media technologies where skipping costs are high.

4.5 Search, Aggregators, and Social Media

Search engines, news aggregators, social media and networks all play an increasingly important role in the consumption of news. While they can be embedded into our baseline model in a natural manner, a complete analysis is deferred to future research. Here, we briefly sketch how these phenomena can be incorporated into our framework.

4.5.1 Search

Search engines, such as Google and Yahoo! currently have a significant presence in the online media, and their share of advertising revenue has grown in recent years (see, e.g., Grueskin et al., 2012). One simple way to embed search into the basic framework is as follows. In 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. The reader can then choose to read the story in the outlet to which he is directed or to perform more searches.

A full analysis of search involves the introduction of special outlets that specialize in search services and have well-specified rules of linking to stories on different outlets. This is particularly relevant in a world with significant uncertainty in the possible stories and media items that can be consumed. We also note that cheap and efficient search can be a useful tool for readers to circumvent the rankings provided by the media outlets, thereby enabling them to consumer stories closer to their preferred bundle.\textsuperscript{16}

\textsuperscript{15}The following controversial quote by US Secretary of State, Hilary Clinton, speaking at the US Senate Foreign Relations Committee in March 2011, reveals her views of too many advertisements on (US) television, although the political context of her comments is clearly very different from our setting:

“[The] viewership of Al Jazeera is going up in the United States because it’s real news. You may not agree with it, but you feel like you’re getting real news around the clock, instead of a million commercials, and, you know, arguments between talking heads, and the kind of stuff that we do in our news which, you know, is not particularly informative to us, let alone foreigners.”

\textsuperscript{16}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), de Cornière and Taylor (2012) 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 of search engines on the web.
4.5.2 Aggregators

In addition to search, news aggregators have also recently gained prominence in the online media market, and including them in our analysis therefore seems worthwhile for understanding online consumption of news and information acquisition. Notice that our basic framework can be viewed as a model between aggregators rather than 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. A full analysis that includes both news producing outlets and aggregators would need to provide more detail into the production process of news, particularly into the costs.\textsuperscript{17} We note, however, that the incentives of news aggregators may be different from those of news producers, which may impact their choice of rankings. Moreover, some aggregators offer their 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. We leave an analysis of the interaction between news producers and aggregators in a context of time constrained consumers for further research.

4.5.3 Social Media

Social networks and forums, such as Twitter, Facebook and blogs in general have risen in popularity as alternatives to traditional media. We do not analyze the richness of the different aspects and alternatives that exist, but instead remark that some of these networks enable consumers to use, access and share the news with more control over what stories they receive. To some extent, this allows readers to influence the rankings of stories. It also permits other consumers to influence their rankings, as is the case with blogs and, to some degree, Facebook. The market then becomes more complex to analyze, as the main media firms must also contend with readers’ choices of re-rankings and news production. We note, however, that a number of these platforms maintain a degree of control over the manner in which news is displayed. To the extent that their incentives may also be to keep consumers reading more ‘news’ stories, similar tensions to the ones described in this discussion may exist. That is, the possible misalignment between ranking stories according to the consumers’ preferences and attempting to keep consumers connected for as long as possible may remain. A theoretical and empirical analysis of this market may be of interest.\textsuperscript{18}

\textsuperscript{17}Dellarocas et al. (2010), George and Hogendorn (2012), Jeon and Esfahani (2012), and Jordan et al. (2012) study aggregators, in settings without time constraints.

\textsuperscript{18}Curran et al. (2012) and Lovink (2011) contain useful analysis of social media; see also Pariser (2011).
4.6 Political Bias and Time Constrained Voters

We have so far focused exclusively on the case in which there is no ideological preference on either the side of the firms or the readers. Recall that we have set $\alpha_k^i = 0$ and $\beta_k^i = 0$, for all topics $k \in K$, in the profit function of every firm $i \in I$,

$$
\Pi^i(\sigma^i|\sigma^{-i}) = \sum_{k \in K}(1 + \alpha_k^i) \sum_{n \in S^i_k} \mu_{n}^{k,i}(\sigma^i, \sigma^{-i}) + \sum_{k \in K} \beta_k^i \sum_{n \in S^i_k} \mu_{n}^{k,i}(\sigma^i, \sigma^{-i}) \lambda_k^i z_n^k.
$$

Parameter $\alpha_k^i = 0$ indicates that the firms do not have a preference for a topic; we could relax this assumption to study the case where the revenue they receive for readership varies across topics. Instead, we maintain this assumption and relax the assumption that $\beta_k^i = 0$, which refers to a preference the firms have over content read by the readers.

Recall that $\mu_{n}^{k,i}(\sigma^i, \sigma^{-i})$ is the share of the readership firm $i$ receives on topic $k$, that $\lambda_n^k$ is newsworthiness, and that $z_n^k$ is content. Setting $\beta_k^i \neq 0$ indicates that firm $i$ considers the share of readers on topic $k$ reads on the sum of newsworthiness weighted by content. This can be interpreted as a proxy for information received by the agent; a more newsworthy story is also more informative, and the content variable $z_n^k$ refers to the intrinsic information transmitted to readers. Hence $\beta_k^i > 0$ for topic $k$ captures an ideological preference for content in one direction (in favor of positive news content on topic $k$), and $\beta_k^i < 0$ captures a preference for content in the opposite direction, as in the case of a left-right political spectrum. This model can therefore easily allow for political preference by the firm. It is straightforward to see that this preference 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 the firms’ preferences, they may still not receive the information that they would like. Moreover, their posterior beliefs would be affected by the firms’ chosen rankings, even when they account for the firms’ strategies.

As an example, suppose that firm $i$ has a monopoly over its readers (i.e. there is a prohibitively high switching cost). There are two states of the world $S_1$ and $S_2$. In state $S_1$, story $(1, z_1^A)$ occurs, and in state $S_2$, story $(1, z_2^A)$ occurs. Suppose that firm $i$ has an ideological preference for readers not to receive the content of story $(1, z_1^A)$ in state $S_1$, and that it is neutral over the content of story $(1, z_2^A)$ in state $S_2$. For instance, suppose that $\beta_A^1 = 1, z_1^A = -1$ and $z_2^A = 0$. 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 he votes accordingly. Finally, assume there are a number of identical, neutral stories in each state, such as stories of topic $B$, where $\beta_B^1 = 0$. Consider now an equilibrium in which the firm places story $(1, z_1^A)$ at the end of its ranking in state $S_1$, and that, similarly, it places story $(1, z_2^A)$ at the end of its ranking in state $S_2$. The skipping costs and preferences are such that the reader never accesses those stories in either state.
It is then clear that, even if a reader is aware of this strategy and is fully Bayesian, he remains with his prior as he receives no information over which state he is in. Consider the extreme case in which, in a context of voting, the reader votes one way given his prior, and another when learning that he is in state 1. Then the ideologically driven media firm affects the reader’s vote, even though the reader is fully aware of the firm’s strategy beforehand. This result further indicates 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. That is, a small direct utility difference for the readers may be due to a large difference in rankings.

Suppose that there is more than one firm to choose from (e.g. with low switching costs), and that these firms have a different ideological preference. Moreover, consider the case in which readers have heterogenous priors over the state of the world. It is immediate that firms with different objective functions may present different rankings. Furthermore, under some conditions, consumers will read from the firm that is closest to their prior, as they believe this firm to be less likely to “conceal” relevant information from them. In other words, this framework is consistent with the empirical observation that readers self-select to acquire news from outlets that “share” their views. This result does not depend on readers having a preference for information that supports their beliefs.

Finally, we note that it is straightforward to incorporate readers’ ideological preferences 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 $k \in K$. A detailed theoretical and empirical analysis of this type of market is deferred to future research. Our aim has been to demonstrate that our framework can be extended in a straightforward way to include ideological preferences on both the firm and the consumer side of the market.

5 Closing Remarks

In order to address the overwhelming abundance of information available today in both new and traditional media, we developed a model that takes, as essential features, consumers that are time constrained and news media firms that primarily rank stories of the day. We modeled the time constrained consumers in a way that accommodates many different types of media. The framework accounts for differences between media types in terms of basic technological costs.

From the resulting baseline framework, we derived a series of properties of the rankings in equilibrium, and conducted comparative statics on the equilibrium rankings over different types of costs. For instance, we highlighted the importance of the cost of skipping stories. For the media types that have high skipping costs (e.g., live broadcast television and radio), the rankings of stories can be less reader-efficient than in media types in which the skipping costs

\footnote{See Prat and Strömberg (2013) for an extensive survey of the literature; see also Hamilton (2004).}
are lower (e.g., online news). This simple observation may be significant in understanding part of the migration away from television and radio to online news consumption. It also captures one of the appealing features to readers of certain media types, and in particular online media. Our results therefore suggest an avenue in which our predictions on different media markets and media types can be tested empirically. In addition, we believe that this overall framework provides a useful, unified way of modeling several aspects of the media.

This paper also emphasized the role of topics for which readers have complementary preferences. Our results suggest that stories from these topics may have a prominent location in firm rankings, even when firms are unbiased. These results also provide a rationale for tabloid news. Testing the empirical strength of these conjectures is outside the scope of this paper, however.

Finally, a main objective of this analysis was to illustrate the flexibility of the framework to incorporate different aspects of the media. In particular, it can be applied to diverse types of consumer preferences and firm incentives. It can be extended further to include search costs and advertisement revenue, as well as various types of media platforms, such as public media, search engines, aggregators, and social media. Moreover, the framework can be placed a political economy setting in which a formal connection between news consumed and voter informativeness can be established. Thus the model can be further developed to analyze the increasing tension between the abundance of information and the scarcity of time of individuals on one hand, and the centrality and potential externalities associated with news media for policy decisions on the other. An in depth analysis of these extensions is deferred to future research.

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:

$$U_t(a_t|s^k_n, H_{t-1}, \sigma) = \sum_{k \in K} \Delta u_k(x^k_t, x^k_{t-1}) - \Delta c(\tau_t, \tau_{t-1}) + EU_{t+1}(a_{t+1}|H_t, \sigma)$$

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

$$U_{t+1}(a_{t+1}|s^k_n, H_t, \sigma) = \sum_{k \in K} \Delta u_k(x^k_{t+1}, x^k_t) - \Delta c(\tau_{t+1}, \tau_t) + EU_{t+2}(a_{t+2}|H_{t+1}, \sigma)$$

is unaltered from (1), 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:

$$U_0(P_0|\sigma) = EU_1(a_{t+1}|H_t, \sigma) = \sum_{k \in K} \Delta u_k(x^k_1, x^k_0) - \Delta c(\tau_1, \tau_0) + EU_2(a_{t+1}|H_t, \sigma)$$

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, nor what other consumers are choosing), finiteness and the fact
that all individuals are Bayes rational with a common prior over the possible states of the world,
guarantees that the game is indeed solvable by backward induction. (Because of independence
the game can be solved separately for each individual.) The corresponding solutions yield a
compact and convex set of possible expected mass of readers, from which a selection with the
desired properties always exists.

Existence of equilibrium in $\Gamma_{ext}$ and $\Gamma$ follows from the finiteness of $\Gamma_{ext}$ and Lemma 3 proved
just above. Clearly $\Gamma$ is also finite.

### A.3 Proof of Proposition 3

Take a profile consisting of reader-efficient rankings $\sigma^*$. As profits are derived solely from the
sum of readers attracted all the different stories, it is not possible to deviate and attract more
readers since the opponent is already offering a reader-efficient ranking. Hence no firm has an
incentive to deviate

### A.4 Proof of Proposition 4

Fix $\nu_{SW}$ and consider a Nash equilibrium profile that maximizes firms’ profits. As there are no
switches by Proposition 5 (the proof, although further below, does not depend on this proof), we
may assume without loss that the equilibrium is symmetric. 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 a equilibrium at $\nu_{SW}'$,
it is because a firm has an incentive to deviate to a strategy, say $\sigma'$, at which it has the same
readers (the ones bookmarked with it) but where these read more stories. (For if a deviation
existed at which it also attracted more readers it would have been a valid deviation to $\sigma$ at the
original costs $\nu_{SW}$, but this violates the fact that $\sigma$ is 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.

### A.5 Proof of Proposition 5

Fix a game $\Gamma$ and a pure Nash equilibrium profile $\sigma$. First, we construct a pure symmetric
profile $\sigma'$ that involves no switches and show that it constitutes a Nash equilibrium that is

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weakly payoff-improving for the firms to \( \sigma \). Next we construct a further pure symmetric profile \( \sigma'' \) that involves no switches and no skips, and show that it is a symmetric Nash equilibrium that is weakly payoff-improving to \( \sigma' \) for the firms.

\( \sigma' \): Consider the profile \( \sigma = (\sigma_1, \sigma_2) \). If there are no switches then we are done since we can take \( \sigma' = \sigma \). But suppose there is a positive mass of readers that switches from say outlet 1 to outlet 2. If there are no switches from outlet 2 to outlet 1, then this would contradict the fact that \( \sigma \) is a Nash equilibrium since outlet 1 would strictly improve its payoffs by offering \( \sigma_1 \) up to the switches and the “non-covered” parts of what the readers see after the switches; it would retain its readers without losing any others. Hence there must also be some states where a positive mass of readers switch from outlet 2 to outlet 1. In fact, there may be several such switches, but suppose there are no more.\(^{20}\) Then consider the following profile \( \sigma' \). Take the same strategies as \( \sigma_1 \) and \( \sigma_2 \) up to the switches and then replace the continuations with the “non-covered” parts of what the readers see on the other outlet after the switches (taking the histories leading to the largest expected numbers of stories read in case of multiplicity). This provides strategies \( \sigma'_1 \) and \( \sigma'_2 \) such that no consumer wants to deviate, as is getting to read same stories as with \( \sigma = (\sigma_1, \sigma_2) \) but without having to switch and thus saving on the switching cost. If the switching cost is sufficiently small then it is easy to see that the new profile \( \sigma' = (\sigma'_1, \sigma'_2) \) indeed constitutes a Nash equilibrium. If the switching cost is not small, meaning that the time cost saved from avoiding the switch allows to actually offer another story to read, then it is easy to see that adding such stories to the profile \( \sigma' \) will yield a Nash equilibrium. To get a symmetric one, take one of pair \( (\sigma'_1, \sigma'_1) \) or \( (\sigma'_2, \sigma'_2) \).

\( \sigma'' \): To get a symmetric Nash equilibrium without skips, take \( \sigma' \) obtained above and remove the stories skipped appending them to the end of the ranking, possibly removing duplicating ones. If there are no other stories that the outlets can get readers to read then we are done; otherwise allow for reranking to take into account the time saved by readers on skipping and switching such that profits are maximized. Choosing again a symmetric profile completes the proof.

**A.6 Proof of Proposition 6**

Choose the switching cost \( \bar{\nu}_{SW} > 0 \) as if the media firms were monopolists. Next fix a firm and consider a strategy \( \sigma_i \) that maximizes the expected number of stories read by its readers in any state. 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, say \( \bar{\sigma}_R \), the reader will always want to read those stories if a permutation is applied to the ranking that inverts the order of one pair of successive stories that (prior to the permutation) are ranked in decreasing order of newsworthiness. This follows immediately from the linearity of the utility function \( u \) and the

\(^{20}\)If there are more, then because of the finiteness of the game we can locate the last such switches and work our way down to the first switches using the same arguments that follow below. We omit the details.
fact that the stories in $\tilde{\sigma}_R$ already all get read. Applying this iteratedly eventually yields a completely increasing ranking of the same stories $\tilde{\sigma}_R$ that readers for sure will want to read. This shows that a payoff-equivalent profile exists where the stories are read in reverse order.

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 suffice to consider the following example. Suppose there are 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

By continuity of the payoffs it suffices to show the case of zero switching cost. Suppose then that $\nu_{SW} = 0$ and suppose there are two outlets of which one is public and the other is a standard outlet with profits as defined in Section 2.2. Then the public outlet has by definition a dominant strategy to choose a reader-efficient ranking. With $\nu_{SW} = 0$, the other outlet has no other choice (if it wants to retain its audience – it cannot take audience away from the public outlet) than to also provide a reader-efficient ranking. This constitutes a Nash equilibrium as both firms retain their audience and cannot improve their payoff by deviating.