Time Scarcity and the Market for News*

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Abstract

We develop a theory of news coverage in environments of information abundance that include both new and traditional news media, from online and print newspapers to radio and television. News consumers are time-constrained and browse through news items that are available across competing outlets, choosing which outlets to access and which stories to read or skip. Media firms are aware of consumers' preferences and constraints, and decide on rankings of news items that maximize their profits. We find that the news consumed in equilibrium is highly sensitive to the details of the environment. We show that even when readers and outlets are rational and unbiased, readers may consume more than they would like to, and the news items they consume may be significantly different from the ones they prefer. Important news items may be crowded out. Next, we derive implications on diverse aspects of current media, including a rationale for tabloid news, a rationale for why readers prefer like-minded news, and how advertising can contribute to crowding out news. We also analyze methods for restoring reader-efficient standards and discuss the political economy implications of the theory.

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1 Introduction

While there is a virtually unlimited amount of information generated and made available daily, people have neither the time nor the capacity to consume or process it all. A crucial role of the media consists of filtering this information and presenting the most relevant news to the public. This role has become increasingly important amidst dramatic technological advances of recent years.[1] Yet, it remains largely unclear how these changes have impacted news coverage and, ultimately, whether readers are better informed, as citizens and voters, as a result.[2]

A central theme of this paper is that there are time costs associated with processing and accessing the news that depend on the media type and platform. Although these costs are typically small and seemingly irrelevant, they can have a significant impact on how news items are ranked. Our main results show that readers may consume more stories than they would like to and on topics different from the ones they prefer. While this need not have a large effect on readers' utility levels, it can radically change stories read. The paper thus highlights a potential fragility in the choice of stories and topics that the press covers most prominently. Given readers' time constraints, there can be systematic crowding out of important news items.

Three features characterize our approach: *(i)* media firms essentially provide an *ordering* of the stories of the day, *(ii)* consumers are *time-constrained* when consuming the news, and *(iii)* they access the news through given *menus of choices* that allow them to read and skip stories or switch and search outlets. These three features provide a unifying lens through which to study digital and traditional media. From these, we derive a minimal model that allows us to study news consumption and production, from print and online news to radio and television. The same framework also applies to other increasingly vital elements of contemporary communication, such as social media, public media, advertising and search. We therefore provide a tractable model of how readers, in diverse settings, browse through news items and how media outlets present their stories in response.

We consider a market for news with profit-maximizing media firms facing utility-maximizing readers. On the demand side, consumers read in a sequential manner, taking into account their time constraints. While they rely on the media outlets' rankings of news items, they browse through the news and decide whether to read or skip articles, to switch to other media outlets or to stop reading the news altogether. Whether the decisions on news consumption are made at a conscious or a subconscious level, the key aspect is that reading and skipping articles and navigating across websites are all costly in time and cognition. These costs may vary with the media platform; for instance, skipping a story in an online newspaper is less costly than skipping one on television. Readers can also switch from one media outlet to another or return to read articles that they previously skipped. An individual's utility from reading an article depends on its "newsworthiness," which is a function

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

[2] See Strömberg (2004), Besley and Prat (2006), DellaVigna and Kaplan (2007) and for early papers modeling the interplay of media and politics; Strömberg and Prat (2013) and Sobbrio (2014b) contain comprehensive surveys of the literature.

of its relevance and entertainment value, and may depend on what they have previously read. We assume, throughout the paper, that consumers are rational, and that they do not misjudge their appraisal of content or underestimate their willingness to read.

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

We show that, despite their lack of bias, firms might not rank stories in the reader-optimal way. Equilibrium rankings may lead consumers to read more stories than they would like, and these stories may cover very different topics from those that readers want. The results are robust and follow from a fundamental misalignment between the consumers' preferences over the stories they wish to read and the firms' incentives to maximize stories read (or, for online media, "page views"). They hold under "perfect" competition or with a zero cost of switching from one outlet to another, even when readers have no uncertainty over the rankings and newsworthiness of the stories; they do not rely on any kind of reader manipulation or deception, since readers are fully aware of the firms' preferences and editorial policies. Somewhat surprisingly, this entails that small changes in time costs of skipping stories or switching outlets can have a large impact on the rankings provided by the outlets and, consequently, on the stories read. Intuitively, readers typically do not have strong enough incentives to seek their most preferred ranking. That is, while the stories read can be on entirely different subjects, direct reader utility itself is *not* significantly changed. But, since this may lead to a large difference in the topics over which readers are informed, the political economics consequences may themselves be important.

To better articulate the type of stories covered more prominently, we introduce a notion of "suspense potential." Intuitively, suspense potential measures how well a story line can keep readers waiting for the more interesting bits. In ranking stories, firms can use suspense to keep readers on their platforms longer. Having first "hooked" the consumer, they move the "punch line" and the more important stories further down their rankings (or delay their broadcast), if the readers' incentives to skip the less relevant news items are not too high. This "best for last" strategy is particularly effective for more entertaining, tabloid-like stories. In addition, firms coordinate their rankings rather than defect to stories that readers would have preferred a priori. Topics that hold more suspense potential can deflect attention from stories that the readers find more newsworthy.

Our framework also provides insight into further key aspects of contemporary media and communication. We focus on three especially natural and relevant ones. First, we explore ways in which reader-efficient rankings can be restored. Importantly, the presence of a public media outlet can lead the firms in the market to provide the reader-optimal ranking, provided the public firm maximizes readers' interests. The mechanism relies on the ease of accessibility of the public media outlet, which indirectly pressures firms and enforces a reader-optimal standard. We also analyze conditions under which pricing can restore reader-efficient rankings. Second, we discuss how our model applies to different media platforms, including traditional media, social media, and aggregators. Lastly, we consider the political economy ramifications of our framework. We place the model in a political economy environment, where newsworthiness can be linked to informativeness, and explore the informational consequences of readers' time constraints. We observe that without any bias, consumers may be uninformed on topics that they consider more important but overly informed on others. In a context of ideological preferences, it follows that consumers may choose outlets that share their views even when they do not derive utility from belief confirmation (Mullainathan and Shleifer, 2005) or other forms of bounded rationality. Rather, the outlets that share their views make it easier for readers to find stories that interest them the most. Our model therefore provides a natural explanation for a preference for like-minded news.

Related literature. This paper relates to different strands of literature. It relates naturally to the economics literature on media bias, which has studied several sources of bias such as government media capture (Besley and Prat, 2006) and revenue or advertiser-driven bias (George and Waldfogel, 2003, Ellman and Germano, 2009, Germano and Meier, 2013) as examples of biases originating on the supply side, or slant towards consumer priors (Mullainathan and Schleifer, 2006) as an example of a bias originating on the demand side. The literature is surveyed in Gentzkow and Shapiro (2008), Blasco and Sobbrio (2012) and Prat and Strömberg (2013). Our paper identifies a new source of bias that derives from time-constrained consumers and technological aspects of processing the news, which can lead to both excessive amounts of news consumed and important news items being crowded out, and which can occur with otherwise fully neutral and rational consumers and firms.[3] We view this as a supply-driven bias. At the same time our paper identifies a new rationale for readers to prefer media outlets with "like-minded news," which is simply that stories that are important to them are more likely to be ranked on top.

The paper also relates to a rapidly expanding literature studying the effects of technological innovations in digital media on news and advertising markets. Athey and Möbius (2012), George and Hogendorn (2012), Dellarocas et al. (2013), Chiou and Tucker (2015) and Jeon and Nazr (2015) study the role of aggregators and hyperlinks as innovations in current news markets; Hong (2012) studies the effects of the adoption of social media platforms such as Twitter, by news media firms, on their online news readership; Athey and Gans (2010) and Athey et al. (2012) study the effects on news readership of innovations in the technology of advertising from a two-sided market perspective.[4] To

[3]The bounded rationality interpretation of scarcity of cognitive resources is also consistent with our model. For the distinct notion of rational inattention used in macroeconomics and finance, see Sims (2003), among others. See Dyson (2004) for a survey on text layouts and reading effectiveness from screens.

[4]Within the broader media and communications literature, Hindman (2009) and Boczkowski (2010) study the consumption and production of (political) news in digital media (see also Hamilton, 2004, Ch. 7); Pariser (2011) discusses the dangers of a filtered and individually targeted internet; Curran, Fenton and Freedman (2012) argue that the internet has not fulfilled many expectations raised; Lovink (2012) discusses media and social networks.

this literature we contribute a novel framework that captures technological innovations through the costs of processing the news, combined with consumers' preferences and time constraints, to derive implications on media coverage. An advantage of our framework is that it can address such issues while keeping track of the two-sided nature of media markets in a tractable manner. In particular, it can be further extended to the above domains of analysis, and particularly advertising, search, social media and news aggregators.

Finally, the recent literature on search diversion and obfuscation in markets with an intermediary is also related to our results on rankings. Ellison and Ellison (2009) provide an empirical analysis of price elasticities and competition between internet retailers that attract customers through a search engine; Armstrong et al. (2009) and Hagiu and Jullien (2011) show how an intermediary platform can have incentives to divert search; Hagiu and Jullien (2014) look at search diversion with competing platforms; Rhodes (2011) stresses the role of prominence in otherwise frictionless markets; De Cornière and Taylor (2014) and Burguet et al. (2015) capture bias originating via advertising, and Eliaz and Spiegler (2011), White (2012) and De Cornière (2015) study the design of search engines and analyze the resulting quality of matches.[5] This literature typically assumes consumers who buy at most one unit of a given product. By contrast, in our model, consumers can consume multiple news items, which are drawn from multiple categories of news topics and that can differ in terms of a further quality dimension, namely, newsworthiness; both the quantities and qualities can matter to our consumers and firms. Moreover, our paper focuses specifically on the market for news and possible political economy implications. Within this context, it studies the effect of sub-optimal rankings of news items from distinct topics on news consumption, and emphasizes the critical externalities that this implies to the general level of informativeness for consumers.

The paper is structured as follows. Section 2 introduces the framework, Section 3 shows the main features, and presents key examples, Section 4 discusses important extensions, and Section 5 concludes. All proofs are in the Appendix.

2 Model

We introduce our model of the market for news, where media outlets rank the news stories of the day, and where time constrained readers access the stories through the given menus of choices. The technological costs of locating and consuming news are relevant and differ across different media types. We develop a common framework that allows us to analyze both new and traditional media.

2.1 Sketch of the Model

Before describing the formal details of our framework, we sketch its functioning at an intuitive level. The model is inspired by digital media for which, on any given website, consumers face a menu

[5] For studies of communication and information overload that consider agents sending information and competing to reach audiences, see van Zandt (2004) and Anderson and de Palma (2012). We avoid this issue by assuming that firms all have access to the same set of stories.

Table 1: Initial history

	BBC News		**The Guardian**	
σ_n	Topic	Headline	Topic	Headline
1	*World*	*Vote Greece*	World	Vote Greece
2	UK	First Female Bishop	UK	Tax Cut
3	World	Greek Singer Dies	UK	First Female Bishop

$\underline{t=1}$: $\tau_0 = 0$, $H_0 = \emptyset$
Legend: *Cursor* / **Story Read** / Skipped / Not Accessed

of choices that allows them to easily access the potentially vast amount of information available. Consider two outlets, such as the *BBC* and the *Guardian*, which decide on a ranking of the given stories of the day. A reader can access several sites, but is assumed to be bookmarked on one of them, say, the *BBC*. When deciding to read the news, she automatically accesses the bookmarked site and sees the headline to the first ranked story, σ_1^{BBC} (*Vote Greece*). She does not see the remaining headlines. This situation is captured by Table 1 (taken from actual, online headlines in January 2015), where the position of the cursor at the beginning of period $t = 1$ is indicated by a *cursive* script, whereas remaining stories that are not yet visible to the reader are indicated in gray. Period t does not reflect time; rather, it is a counter of the sequence followed by the reader.

At the beginning of period $t = 1$, the reader has not yet read anything nor spent any time viewing headlines. Her history set is empty ($H_0 = \emptyset$), and the time spent processing news is $\tau_0 = 0$. She can decide whether to read the first headline ($a_1 = RD[\sigma_1^{BBC}]$), skip it ($a_1 = SK[\sigma_1^{BBC}]$), switch to the other outlet ($a_1 = SW[\sigma_1^{GUA}]$), or she can already choose to stop reading altogether ($a_1 = ST$).

The reader makes her choices sequentially, until she chooses to stop. Suppose that she decides to read the first story on the *BBC*, $a_1 = RD[\sigma_1^{BBC}]$, as represented in Table 2. Her history now includes one story, ($H_1 = \{RD[\sigma_1^{BBC}]\}$), and the cursor is at σ_2^{BBC} (*First Female Bishop*). Her time cost thus far is $\tau_1 = \nu_{RD}$, the cost of reading one story. Suppose that she then decides to switch outlet, $a_2 = SW[\sigma_1^{GUA}]$), the cursor would move to σ_1^{GUA}, and her associated history is $H_2 = \{RD[\sigma_1^{BBC}], SW[\sigma_1^{GUA}]\}$. If her next action is to skip the story, $a_3 = SK(\sigma_1^{GUA})$, then the cursor moves to story σ_2^{GUA}. Let her next two actions be to read that story, $a_4 = RD[\sigma_2^{GUA}]$, and then stop, $a_5 = ST$. Her total time spent processing the news is $\tau_5 = 2\nu_{RD} + \nu_{SW} + \nu_{SK}$, which is the time spent reading two stories, switching outlets once, and skipping one story; see Table 3. Her final utility is then the sum of the utility derived from the stories read minus the cost of the total time spent processing the news:

$$U = u_{World}(\lambda_1^{BBC}) + u_{UK}(\lambda_2^{GUA}) - c(2\nu_{RD} + \nu_{SK} + \nu_{SW}).$$

In making her news consumption choices, the reader can be viewed as optimizing either one of two problems: she can be seen as following a marginal cost-marginal benefit analysis at every step in the

Table 2: History after first BBC story read

	BBC News		The Guardian	
σ_n	Topic	Headline	Topic	Headline
1	**World**	**Vote Greece**	World	Vote Greece
2	*UK*	*First Female Bishop*	UK	Tax Cut
3	World	Greek Singer Dies	UK	First Female Bishop

$\underline{t=2}$: $\tau_1 = \nu_{RD}$, $H_1 = \{RD[\sigma_1^{BBC}]\}$; $a_1 = RD$
Legend: *Cursor* / **Story Read** / Skipped / Not Accessed

Table 3: Final history

	BBC News		The Guardian	
σ_n	Topic	Headline	Topic	Headline
1	**World**	**Vote Greece**	World	Vote Greece
2	UK	First Female Bishop	**UK**	**Tax Cut**
3	World	Greek Singer Dies	*UK*	*First Female Bishop*

$\underline{t=6}$: $\tau_5 = 2\nu_{RD} + \nu_{SK} + \nu_{SW}$, $H_5 = \{RD[\sigma_1^{BBC}], SK[\sigma_2^{BBC}], SW[\sigma_1^{GUA}], RD[\sigma_1^{GUA}], ST\}$; $a_5 = ST$
Legend: *Cursor* / **Story Read** / Skipped / Not Accessed

sequence, or she can be seen as maximizing her final utility. As we later discuss, both interpretations are consistent with our model, and lead to the same outcome.

2.2 News Sources and Stories of the Day

On any given day, the **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, so that $S = S_A \cup S_B$, where $S_k \subset S$ are stories on topic k, with $k \in K = \{A, B\}$. We implicitly assume that the news sources provide stories to all media outlets. These sources could be governments, corporations, or news agencies such as *Reuters* or *Associated Press*. Topics could represent broad categories, such as international and domestic news, politics or entertainment, or they could be more specific categories, such as news in the Middle East. We also assume that S has cardinality N.

The elements of S are denoted by s_n^k and are characterized by a level of **newsworthiness** $\lambda(s_n^k) \in [0, \overline{\lambda}]$, for some $\overline{\lambda} \in \mathbb{R}_+$. Newsworthiness measures how important and informative a story is to readers, and is ultimately what readers derive utility from; it is not an objective measure of quality, but rather it reflects the viewers' preferences.

In the basic model, we assume that all agents (media outlets and readers) know the state of the world and hence the whole set S. As is standard in this literature, we assume that agents need to read a story in order to consume the content. Appendix A.2 extends the model to allow readers to have uncertainty about the true state, and update their beliefs as they read and skip stories.

2.3 Media Outlets

There are two firms, denoted $i \in I$, where $I = \{1, 2\}$. Their strategies consist in fully ranking the stories in S. Formally, if $\mathcal{P}_N$ denotes the set of total strict rankings of the elements of S, then a **strategy** of firm i is such a ranking $\sigma^i \in \mathcal{P}_N$, which is simply a completely ordered N-tuple of stories of the day; also set $\sigma = (\sigma^i, \sigma^{-i})$, where $\sigma^{-i} \in \mathcal{P}_N$ is the ranking of i's opponent. An outlet here cannot carry out its own investigation and cannot magnify or trivialize the newsworthiness of stories; it only has the technology to rank given stories in the order in which readers view their headlines. The notion of not reporting a story effectively corresponds to leaving a story to the end of the ranking.

Given the set of stories S, media outlet i chooses σ^i to maximize **expected profits**, which, with a unit price per story read and zero fees collected from viewers, reduces to:[6]

$$\Pi^i(\sigma^i|\sigma^{-i}) = \sum_{k\in K} \sum_{s_n^k \in S_k} \mu_n^{k,i}(\sigma^i, \sigma^{-i}) \, , \tag{1}$$

where $\mu_n^{k,i} : (\mathcal{P}_N)^I \to [0, 1]$ is the mass of readers that firm i expects will read story s_n^k from it. In our basic model, a firm's profits are a function of the readership it obtains on all its stories.

2.4 Readers

We formalize readers' preferences and choices in accessing the news, as sketched in Section 2.1. While appearing complex on the surface, this framework precisely captures the way agents maximize the utility of reading newsworthy stories minus the time costs of doing so. It also takes into account that readers keep track, consciously or subconsciously, of the history of actions taken and the options available.

Readers' actions. There is a continuum of readers normalized to mass 1. Let M_1 and $M_2 = 1 - M_1 \in [0, 1]$ denote the mass of readers that first access outlets 1 and 2, respectively. We use the term "bookmark" to denote the first outlet accessed by a reader, which, for the moment, is exogenously given.[7] Periods at which readers make their choices are denoted $t \in \{1, \ldots, T\}$, but these periods need not correspond to a notion of time. Rather, they keep track of the sequence of the reader's choices. A period refers to the stage at which the reader takes an **action** $a_t \in \{RD, SK, SW, ST\}$ to **read** a story (RD), to **skip** it (SK), to **switch** to a not previously accessed outlet (SW) or to **stop** reading altogether (ST). Readers derive utility from reading articles and incur a time cost from the actions RD, SK and SW. ST terminates the reader's game. We normalize the agent's continuation

[6] We consider in Section 4 more general profit functions that include factors such as viewer fees and revenues deriving from airing time-consuming advertisements.

[7] The bookmark partly covers other factors of reader preference, such as preference for a reading style, ease of access or being accustomed to a newspaper's layout. We consider below the important case in which readers can switch to other outlets at zero cost. Effectively, this also covers the case in which the bookmarks are endogenous.

utility of stopping to 0. Note that the firm's choice of ordering has taken place *before* the reader's decision, and so the firms do not respond to each reader's choice by reordering the stories.[8]

At any period t, the reader has **history** H_{t-1} of all the stories previously read or seen the headlines to. For any action $a_t \in \{RD, SK, SW, ST\}$ taken in period t, given that the reader is observing headline s_n^k, the pair $\{s_n^k, a_t\}$ is appended to his history so that $H_t = \{\{s_n^k, a_t\}, H_{t-1}\}$. 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, described below, determine the position of the reader's **cursor** after period t:

RD When a reader chooses to read a story, he observes the next story of the outlet's ranking; given strategy $\sigma^i = (\sigma_1^i, ..., \sigma_N^i)$, if at time t he reads story σ_n^i, then the next observed story is σ_{n+1}^i, where $\sigma_n^i = \emptyset$ for $n > N$, $i \in I$;

SK when a reader skips to another story, he observes σ_{n+1}^i;

SW when a reader switches from outlet i to a thus far *unopened* outlet $-i$, he observes the first headline of outlet $-i$, σ_1^{-i}.

Readers' preferences. The physical length of time of any period t depends on the action a_t chosen by the reader in that period. The variable that keeps track of **physical time** is $\tau_t \in \mathbb{R}$, which measures the time spent reading, skipping and switching by the end of period t. Set $\tau_0 = 0$ and define $\tau_t = \tau_{t-1} + \nu_{a_t}$, where time spent as a function of the action taken satisfies $0 \leq \nu_{SK} \leq \nu_{RD}$ and $0 \leq \nu_{SW}$. In words, it is never more costly to skip a story than to read it, and costs are never negative. We also keep track of the aggregate amount of news consumed on topic $k \in K$ by the end of period t. Specifically, we keep track of the total amount of **news consumed** x_t^k on this topic, in all periods up to and including period t. This total amount is expressed as

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

where $x_0^k = 0$.

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

$$U_t(a_t | s_n^k, H_{t-1}, \sigma) = \sum_{k \in K} \triangle u_k(x_t^k, x_{t-1}^k) - \triangle c(\tau_t, \tau_{t-1}) + EU_{t+1}\left(a_{t+1} | H_t, \sigma\right), \tag{2}$$

where $\triangle u_k(x_t^k, x_{t-1}^k) = u_k(x_t^k) - u_k(x_{t-1}^k)$ and $\triangle c(\tau_t, \tau_{t-1}) = c(\tau_t) - c(\tau_{t-1})$. As discussed in the next

[8]As the media's online technology improves, their ability to re-order the stories to fit a specific reader becomes increasingly more relevant. This type of technology does not feature in the present model, but it would not impact the results. We return to this point in Section 3.4.

subsection, the reader effectively considers the added instantaneous benefit, $\triangle u_k(x_t^k, x_{t-1}^k)$, minus the instantaneous cost, $\triangle c(\tau_t, \tau_{t-1})$, plus the future expected utility.

We assume that the instantaneous utility function, $u_k(\cdot)$, is increasing ($u_k'(\cdot) > 0$) and twice continuously differentiable, for $k \in \{A, B\}$. If $u_k''(\cdot) = 0$, then the agent's preference for stories on topic k is independent of what he has previously read. If $u_k''(\cdot) > 0$, then they are complementary; having already read stories on topic k increases the marginal utility of additional stories. We also refer to the topic with complementary stories as one for which readers have **curiosity** preferences: their interest in the subject grows as they read about it. If $u_k''(\cdot) < 0$, then the agent has diminishing marginal utility of reading additional stories on a topic. We assume that $u_A''(\cdot) = 0$ and focus more on the curiosity case for topic B. We further assume that the costs are increasing, $c'(\cdot) > 0$, and (weakly) convex, $c''(\cdot) \geq 0$. Finally, we assume that the agent chooses to stop at any point ($a_t = ST$), then he cannot return to reading in the future, and his expected utility from that period onwards is $EU_t(s_n^k, a_t | H_{t-1}, \sigma) = 0$.

Properties of readers' preferences. There are different, but equivalent, interpretations that apply to the utility function described above. The first is the notion that the agent sequentially performs, in any "period" t, a marginal benefit-marginal cost analysis. That is, he makes his news-consumption decision progressively, as he navigates through the websites. Before deciding whether to read a story on topic k, he considers the additional instantaneous utility he would receive from $\triangle u_k(x_t^k, x_{t-1}^k)$, added to his expected future utility, $EU_{t+1}(a_{t+1} | H_t, \sigma)$. He weights this marginal benefit against the marginal cost of the additional time it would take to read this story, $\triangle u_k(x_t^k, x_{t-1}^k)$. The second interpretation is that the reader is maximizing, in a standard way, his ex-ante utility function for every possible terminal history. That is, he maximizes $\sum_{k \in K} u_k(x_T^k) - c(\tau_T)$, his expected utility of total (ex-post) news read minus the total (ex-post) cost incurred. This second approach is not always thought of as being sequential, but the two methods lead to identical behavior.

We summarize the basic properties of readers' preferences as follows: *readers' preferences are dynamically consistent, and their optimal plans of action maximize ex-ante expected utility from reading newsworthy stories.* (A more formal discussion is in Appendix B.1.) In other words, decisions taken by an agent at different points in time are all consistent with one another.

2.5 Timing and Equilibrium

The timing of the game is as follows:

Stage 1 Given the set of stories S, the media outlets simultaneously choose the rankings $\left(\sigma^i(S)\right)_{i \in I}$ of the stories. The rankings are observed by all parties.

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

Stage 3 Final payoffs of firms and consumers are realized.

This leads to an extensive-form game of complete and imperfect information Γ_{ext} between media outlets and readers. Given media outlets' strategies in stage 1 and given that consumers are individually negligible and independent of each other, consumers' expected demand is always well-specified and straightforward to derive (see Appendix B.2). Hence, the expected reader traffic going to any given media outlet as a function of the ranking strategies is also always well-specified (these are the maps $\mu_n^{k,i}(\sigma^i, \sigma^{-i})$ defining firms' profit functions in Section 2.3).[9] This allows us to reduce the overall extensive-form game Γ_{ext} to a simultaneous game of complete information Γ between just the media outlets. It is easy then to see that the game Γ always has a Nash equilibrium, possibly in mixed strategies. Although not always necessary, we assume throughout that a pure strategy equilibrium exists.[10] When conducting a welfare analysis and when confronted with multiple equilibria, we select those that generate the largest profits to the media outlets.

3 Technology, Rankings and News Acquisition

We present here our key results. First, we establish some expected benchmark results on reader-efficiency and coordination of rankings across outlets. We then show both formally and by means of simple examples how significant inefficiencies can occur due to consumers' time constraints. The source of the inefficiency stems from the tension between consumers' preference to read the most newsworthy stories and firms' preference to have consumers read as many stories as possible. As will become clear, firms have incentives to delay the more newsworthy stories and, in some cases, to replace them with a different set of stories. High skipping costs give firms a greater margin to apply such a strategy. As for switching costs, they capture the degree of competition between firms: high switching costs mean that firms have captive audiences, and as switching costs decrease, competition intensifies. We show that reader inefficient equilibrium rankings can persist even when competition is high.

3.1 Reader-Efficiency and Coordination Benchmark

The following benchmark results are largely in line with intuition. Lower costs of skipping stories and switching outlets are generally beneficial for consumers and not for firms. Skipping costs bound the maximal welfare loss for readers when the number of stories available to firms is fixed. When skipping

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

[10] See Reny (1999) for a set of sufficient conditions for the existence of pure strategy equilibria and symmetric pure strategy equilibria. Applied to our (discrete) setting, these conditions yield existence of almost pure strategy equilibria in the sense that they involve mixing between at most two nearby rankings. This requires to first strictly order the strategy space $\mathcal{P}_N$ and then to convexify the ordered space by allowing to mix between neighboring (and therefore typically very similar) strategies. Note that all our examples have pure strategy equilibria.

costs are zero, reader efficiency – that is, a utility-maximizing ranking – is always achieved. However, intense competition in the form of zero switching costs does not guarantee that profit-maximizing equilibrium rankings are reader-efficient.

Proposition 1 (**Skipping/switching cost and reader-efficiency**). *For any given game* Γ*, there exists a* $\bar{\nu}_{SK} > 0$ *(*$\bar{\nu}_{SW} > 0$*) such that for any* $\nu_{SK} < \bar{\nu}_{SK}$ *(*$\nu_{SW} < \bar{\nu}_{SW}$*) there exists a reader-efficient Nash equilibrium of* Γ*. Moreover, if* $\nu_{SK} = 0$*, then all Nash equilibria are payoff-equivalent to the reader-efficient ranking. The latter need not hold for* $\nu_{SW} = 0$*.*

This confirms the intuition that lower skipping costs and higher intensity of competition, represented by lower switching costs, tend to yield equilibria closer to the reader-efficient ones, always reaching the reader-efficient level when $\nu_{SK} = 0$, but not necessarily when $\nu_{SW} = 0$.

Proposition 2 (**Skipping/switching cost and welfare**). *For any given game* Γ*, assuming that there are no switches in equilibrium,*[11] *firms' expected profits at the profit-maximizing Nash equilibria are weakly increasing in the skipping cost* ν_{SK}*, and readers' expected utilities are weakly decreasing. The same holds for the switching cost* ν_{SW}*.*

This shows that lower skipping and/or switching costs make readers (weakly) better off and firms (weakly) worse off, reaching monopoly profits for the firms when these costs are sufficiently large.[12] In fact, skipping costs bound the utility loss of the readers. It is easy to see that, if there are N stories, then, for any given game Γ and Nash equilibrium σ of Γ, the expected welfare loss to any reader from σ relative to the reader-efficient strategy σ^* is bounded above by $2N \cdot \nu_{SK}$, for any $\nu_{SK} \in \mathbb{R}$. This result is general since, at worse, the reader can skip all N stories and then read the ones he prefers. Thus reducing the skipping cost always results in a welfare improvement for readers in terms of bounding the welfare losses.[13] Maintaining that firms cannot conceal stories, agents always get the reader-efficient ranking in the limit when $\nu_{SK} = 0$. They can skip all the stories they do not wish to read at no cost, and read the utility maximizing ones. We also emphasize that a small bound in utility loss does not in itself mean that the consumer reads articles close to his preferred bundle; in fact, they may be very different even if the bound is small.

The extent to which skipping costs are decreasing with technological advances is ambiguous. It is unclear whether online newspapers have lower skipping costs than traditional print, especially with the current trend of online videos and varying screen sizes. We elaborate on comparing different skipping costs and media types in Section 4.2, but note that to the extent that they can, media firms have incentives *not* to make skipping costs too low.[14]

[11]See Proposition 3 for sufficient conditions ensuring no switching.

[12]Note that with heterogeneous readers, firms may prefer not to have too high a skipping cost, as they may lose consumers who would read some stories that are not ranked sufficiently prominently for them; see Section 3.3.

[13]However, if N, the number of stories generated, were to increase, then the maximum welfare loss would *increase*. Therefore, while immediate, this result foreshadows the positive and negative aspects of technological advances, which we return to later.

[14]In practice, with heterogeneous readers, firms would also not want to make skipping costs too high; see Section 3.4.

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

Proposition 3 (Coordination benchmark). *For any given game Γ, and at any pure Nash equilibrium σ of Γ, both firms have the same profits per reader, and no switches occur. Moreover, for any such Nash equilibrium σ of Γ, there always exists a pure Nash equilibrium σ' with $\sigma'_1 = \sigma'_2$ that also involves no skips and is weakly Pareto-improving for all market participants.*

This result holds for any level of switching or skipping costs and, thus, provides a first rationale for why news segments across outlets may be similar in practice. Clearly, with heterogeneous readers, differentiation may obtain, as we discuss in Section 3.4. Notice also that, while a reader-efficient equilibrium exists for low switching costs, it is generally *not* the case that the natural Nash equilibria are reader-efficient, including in the limit where $\nu_{SW} = 0$. This is illustrated in the example in Section 3.2 below. On the other hand, zero skipping costs always yield reader-efficient outcomes.

3.2 Reader-Inefficiency

We now turn to reader-inefficient aspects of equilibrium rankings. We show that, quite generally, readers may read too many stories and on the wrong topics. This holds within our benchmark model with no uncertainty, with neutral firms that maximize readership and readers that derive utility from newsworthy stories.

In order to induce readers to read as many stories as possible, firms' strategies for ranking stories involve delaying the most important ones until further down the rankings. Before analyzing the firm's optimal strategy in Section 3.3, we here focus on the inefficiencies that can arise from the misalignment of preferences between firms and consumers. We start with a particularly simple case that provides intuition on the constraints that govern the number stories that firms can make readers consume: all stories are on topic A, and both the utility and the cost functions are linear. Then, characterizing how readers may read "too many" stories is straightforward.

Proposition 4 (Extra stories read). *Let Γ be a game with high switching cost $\nu_{SW} > \bar{\nu}_{SW}$, for some $\bar{\nu}_{SW} > 0$, and suppose there are only stories on topic A with readers that have utility function $u_A(x) = x$ for such stories and cost function $c(\tau) = \tau$, and let s^A_{max} be a story on topic A of maximum newsworthiness $\lambda(s^A_{max}) = \lambda^A_{max} > 0$. Then a necessary and sufficient condition on the newsworthiness of a story s^A_{extra} on topic A to be inserted before the most newsworthy story such that s^A_{extra} and s^A_{max} are both read in equilibrium is*

$$\lambda(s^A_{extra}) \geq \nu_{RD} - \nu_{SK},$$

where the reading and skipping costs satisfy $0 < \nu_{SK} < \nu_{RD} < \lambda^A_{max}$. The maximum number of extra stories of minimum newsworthiness $(\nu_{RD} - \nu_{SK})$ that can be inserted such that they are all read, *together with the most newsworthy story, is* $\frac{\lambda^A_{max} - \nu_{RD}}{\nu_{SK}}$.

In words, in the linear case with the parameters above, normalized for simplicity, the firms' strategy for making consumers read more is to provide them with stories earlier in the ranking, before the most newsworthy story. The reader here does not wish to read these stories; in fact he derives *negative* utility if their newsworthiness is close to $\nu_{RD} - \nu_{SK}$. For instance, in the case of a story of newsworthiness $\nu_{RD} - \nu_{SK}$ itself, the instantaneous utility (instantaneous benefit minus instantaneous cost) is $-\nu_{SK}$. But since skipping the story would also lead to the same instantaneous utility, the reader is indifferent. The maximum such stories that the reader can be made to read before the most newsworthy one is $\frac{\lambda^A_{max} - \nu_{RD}}{\nu_{SK}}$ because following them with a story of newsworthiness λ^A_{max} would lead precisely to zero *total* utility if the agent were to read them all. Any additional stories will lead to negative total utility. Therefore, if any such stories were added, the reader would prefer not to read at all.

The simple linear case cannot capture the fact that, in some cases, the reader not only reads too much, but also may read the "wrong" stories. This requires non-linear utility and time cost functions, as the next proposition shows. We say that the equilibrium ranking σ *crowds out* story s^A if s^A is read under the reader-efficient ranking σ^*, but not read under σ, nor under any other ranking σ' that is payoff-equivalent to σ for the firm.

Proposition 5 (**Stories crowded out**). *Let* Γ *be a game where readers have utility function* $u_A(x) = x$ *for stories on topic* A*, and there is one story* s^A_{max} *on topic* A *of maximum newsworthiness* $\lambda(s^A_{max}) = \lambda^A_{max} > 0$*. Then, a necessary condition for story* s^A_{max} *to be crowded out is that the utility function* $u_B(\cdot)$ *for stories on topic* B *and the time cost function* $c(\cdot)$ *both be convex functions (on some domain).*

Crowding out a more newsworthy story on topic A requires curiosity (convex) preference for stories on topic B as well as strictly convex time costs, on part of the domains of $u_B(\cdot)$ and $c(\cdot)$, respectively (i.e., neither $u_B(\cdot)$ nor $c(\cdot)$ can be everywhere weakly concave). We now illustrate different ways in which reader inefficient rankings can arise by means of a stylized example. This example also serves to show the strategy used by firms to rank stories, which we formalize in Section 3.3.

Example setup. There are two media firms, $i \in I = \{1, 2\}$, which can report on two topics, $k \in K = \{A, B\}$, although we also consider the case in which there are only stories on A. On each topic the outlets have access to (potentially many) stories of three types, namely, stories of minimum, medium and maximum newsworthiness, satisfying

$$0 < \lambda^k_{min} < \lambda^k_{med} < \lambda^k_{max}, \quad \text{for } k \in K,$$

Readers are homogeneous and have utility functions $u_A(x) = x$ over topic A and $u_B(x) = 2x^2$ over topic B, and their time cost function is given by $c(\tau) = 4\tau^3$. We also assume, unless otherwise stated, that $\nu_{RD} = 0.3$ and $\nu_{SK} = 0.05$.

One topic: too many stories read. To illustrate how firms can induce consumers to read extra stories, suppose the state of the world has three stories, all on topic A:

$$S = \left\{s_1^A, s_2^A, s_3^A\right\}$$

with newsworthiness $\lambda(s_1^A) = \lambda_{min}^A = 0.3$, $\lambda(s_2^A) = \lambda_{med}^A = 0.7$ and $\lambda(s_3^A) = \lambda_{max}^A = 1.7$, respectively. We adopt throughout the convention that the indices are ordered by increasing newsworthiness. The reader prefers to read only the most newsworthy story, s_3^A, and stop. The reader-efficient ranking therefore consists of any ranking that places story s_3^A first, such as:

$$\sigma^* = \left(\boldsymbol{s_3^A}, s_1^A, s_2^A\right).$$

We use bold script to indicate stories read, which is story s_3^A for ranking σ^*. As is consistent with Proposition 1, ranking σ^* constitutes a Nash equilibrium for a sufficiently small skipping cost.

To show how the reader can be induced to read too many stories, assume instead that the skipping costs are $\nu_{SK} = 0.05$ (or higher), which suffices here to ensure that he does not skip any story. Let the switching costs ν_{SW} be high enough to ensure that the reader never switches. Each firm effectively has a monopoly over its readers. Firms can then maximize profits using the following ranking:

$$\hat{\sigma} = \left(\boldsymbol{s_2^A}, \boldsymbol{s_3^A}, s_1^A\right).$$

The reader then reads the first two stories, s_2^A and s_3^A, even though he would have preferred to read only s_3^A. Firms can effectively induce the consumer to go through a less newsworthy story before reading a more newsworthy one. That is, they rank stories from least to most newsworthy, among the stories that are actually read. If the firm had placed the most newsworthy story first, as in ranking σ^*, then the reader would not have read any other.

If instead the skipping cost is much lower, say, $\nu_{SK} = 0.01$, then the firms cannot get the reader to read s_2^A, as he would simply skip it. Hence, the skipping cost ν_{SK} plays an important role in determining the firm's ranking. When ν_{SK} is low, it is more difficult for firms to make customers read more than they want to. But as ν_{SK} increases, the firms gain control over what the consumers read because it is more costly to skip less desirable stories. This can lead to very different rankings across media platforms with different skipping costs, such as online news compared to broadcast television. We return to this point in Section 4.2.

Two topics: too many stories read on the wrong topic. So far the example showed how due to nonzero skipping costs, the firm can induce readers to (rationally) read extra stories. Now we add stories from a second topic, for which the reader has convex preferences, to illustrate how readers may be induced to not only read more stories than they would prefer, but also all on the "wrong" topic, even as competition increases. Suppose the skipping cost is again $\nu_{SK} = 0.05$, and consider a state of the world:

$$S' = \{s_1^A, s_2^A, s_3^A, s_1^B, s_2^B, s_3^B\},$$

where we have added to state S above three stories on topic B, s_1^B, s_2^B and s_3^B, with newsworthiness $\lambda(s_1^B) = \lambda(s_2^B) = \lambda(s_3^B) = \lambda_{med}^B = 0.5$.[15] As before, the consumer still prefers to read only story s_3^A and stop. But for high skipping costs ν_{SK} and high switching costs ν_{SW}, firms will choose to rank the three stories from B first, and consumers read only those stories:

$$\hat{\sigma}' = \left(\boldsymbol{s_1^B}, \boldsymbol{s_2^B}, \boldsymbol{s_3^B}, s_1^A, s_2^A, s_3^A\right).$$

In other words, although consumers read more stories than they would like to, they do *not* read their most preferred story. When consumers read on a topic for which they have curiosity preferences, it becomes relatively more interesting. In this example, after reading stories s_1^B and s_2^B, the reader has a higher marginal utility from reading story s_3^B than from reading the most newsworthy story from topic A, s_3^A, even though ex-ante he would have rather read only s_3^A. This result does not rely on any mistake or dynamic inconsistency by the reader, or any deception by the firm. It is clear that topics for which agents have curiosity preferences are more easily used by firms to induce consumers to read more; we return to this point when discussing suspense potential.

Persistence of inefficiencies. These inefficiencies persist when competition intensifies, which is captured by a reduction of the switching cost ν_{SW}. They are present even in the limit of "perfect competition", or, more precisely, when the switching cost is zero, $\nu_{SW} = 0$. To see this result, suppose that both firms have the same measure of bookmarked consumers, $M_1 = M_2 = 1/2$. Then, both firms choosing the monopoly strategy of rankings the three of topic B first constitutes a Nash equilibrium. A firm can only profitably deviate by capturing the other firm's market share, but there is no collection of two stories that the reader would prefer to the three of topic B. The only possible deviation is to have the consumer read only the most newsworthy from topic A, s_3^A. Firm 1 will not deviate to this strategy when $M_1 > 1/3$, because the increase in market share is more than offset by the decrease in stories read. Similarly, firm 2 will not deviate from strategy $\sigma_2 = \hat{\sigma}$ when $M_2 > 1/3$ (or equivalently, $M_1 < 2/3$). Since $M_1 = M_2 = 1/2 \in (1/3, 2/3)$, neither firm deviates.

The result does not hinge on there being two firms, or on the assumed range $(1/3, 2/3)$ of the measure of readers. A similar equilibrium can easily be sustained with more firms, or for a larger range, with the inclusion of more stories. The main feature of this equilibrium is that firms are willing to lose readers in exchange for more stories read per reader kept. Moreover, since the costs are not only of readers' time but also of their attention, we do not expect the cost to reach zero. Hence, even with competing outlets, consumers may read too many stories, and these may not be the ones they would like to read. It is the case, however, that as the market share of one firm increases, then, for sufficiently low ν_{SW}, the other firm has larger incentive to undercut the opponent by providing a

[15] Notice that we do not compare newsworthiness *across* topics directly because utilities u_A and u_B are different.

ranking preferred by the reader.[16]

Curiosity, story endowment, and tabloid news. Demand for news on a given day often depends on the stories consumed on previous days. We take this into account by keeping track of the "endowment" of stories read. So far we have assumed that $H_0 = \emptyset$, meaning that consumers' history did not include any story read prior to $t = 1$, and thus $x_0 = 0$. But it is often natural to allow for $H_0 \neq \emptyset$ and $x_0 > 0$. Suppose, then, that agents are endowed with a story, at no additional time cost. For instance, an individual who follows the presidential elections is essentially endowed with past stories on the topic. If these stories are in topic A, then the story endowment has no relevance. If the endowment is in topic B, inducing curiosity, then it can impact readers' choices. In our running example, it is straightforward to see that a large enough story endowment in topic B implies that the reader's preferences would change to preferring the three stories from topic B to any from topic A.

In a political economy setting, a candidate may gain from providing a relatively entertaining, but politically irrelevant, minor "gaffe" to shift the readers' attention away from a deeper, politically more problematic story about actual policies. Media firms may also have a preference for such occurrences to the extent that these increase the readers' inclination to consume more stories. This identifies an important further aspect *"tabloid"* news outlets, namely, that of leading readers to "follow-up" on stories. This increasingly relevant part of online news is naturally captured by our notion of curiosity preferences. Moreover, these news outlets often use an entertaining and sensationalist style of writing to increase the readers' curiosity. Our baseline model can be extended to allow firms to increase a story's newsworthiness through writing style, or to affect the distribution of newsworthiness within a topic. The use of such strategies would induce consumers to ultimately read more stories.

Curiosity assumption: discussion. All else being equal, topics over which individuals have curiosity preferences are favored by firms because they are more "attention-grabbing" – as consumers read more stories on such topics, they become relatively more interested in the topic compared to others. A simple way of capturing this is through the notion of *suspense potential*, which we formalize below. In essence, stories with more suspense potential are also attention-grabbing, in that they are structured to keep readers interested for longer, as they wait for the "punch line." This notion applies to *both* topics A and B, independent of the shape of the preferences.

As a concrete example, consider the case of the death of television celebrity Anna Nicole Smith on February 8, 2007. During just over three weeks, an estimated 32% of Fox News Channel's coverage, 21% of MSNBC and 14% of CNN's coverage were dedicated to it (PEJ, 2007). In aggregate, nearly a quarter of the United State's cable television's airtime was devoted to this topic, even though 71% of respondents stated lack of interest in the story, according to CNN own's polls. Important events

[16] In the limit when $\nu_{SW} = 0$, if inefficient equilibria exist, then they would persist even when allowing for mixed strategy deviations. Consider a deviation in which a firm provides the reader-efficient equilibrium with arbitrarily small probability ϵ, so as to capture all the market. This deviation is not profitable if the reader's strategy is to switch back (at no cost) to his original outlet when he observes an "inefficient draw" of an outlet after a switch. We also note that this mixture is difficult to commit to in practice, since an editorial policy that allows for such mixing would amount to an admission by the media outlet that it is not presenting the best reporting that it could.

that received much less coverage include the race to the White House, events in Iraq and Iran, the agreement with North Korea to dismantle its nuclear facility, the IPCC's confirmation of man's role in causing global warming, also, the combined coverage of Russia, China and India barely reached one percent during those weeks. The subject of Anna Nicole Smith is well-known for having been particularly suspenseful in colloquial terms; it is also in line with our formal definition below.

3.3 Ranking and Suspense

Firms follow general rules in the way they present stories to readers. Some features of stories and topics hold special appeal to firms but not necessarily to consumers. For simplicity, we focus on the case of high switching costs (monopoly outlets). Then, firms rank the stories that consumers will read from *least* to *most* important. That is, they order them in increasing order of relevance, and they leave "the best for last" in order to lure consumers to read as many extra stories as possible. In particular, the following *"reverse-order"* result holds for stories read.

Proposition 6 (**Best for last**). *Let Γ be a game with high switching cost $\nu_{SW} > \bar{\nu}_{SW}$, for some $\bar{\nu}_{SW} > 0$, and suppose that $u_k''(\cdot) \geq 0$, for each topic $k \in K$. Then:*

(a) For any Nash equilibrium σ of Γ, where m_k stories are read for each topic $k \in K$, there exists a payoff-equivalent one, where, for each topic, the m_k stories read are the m_k most newsworthy stories on that topic, and are also ordered by increasing newsworthiness within that topic (stories are not necessarily grouped by topic).

(b) The converse does not hold; that is, for any Nash equilibrium σ of Γ, where stories read are ranked by increasing order of newsworthiness within topic, there need not exist a payoff equivalent Nash equilibrium, where the same stories are ranked by not necessarily increasing order of newsworthiness within topic.

This result simplifies considerably the algorithm used by firms to determine which stories to provide, as discussed further below. It is also common for radio or television news stations to leave the main story to the end of a news segment after having announced it at the beginning. In addition, events such as the Academy Awards announce the winners of the most important categories at the end, and cinemas show the main feature after having shown trailers and advertisements. Similarly, in online media, individual stories in audio or visual format are often preceded by advertisements and other less relevant stories.

While this "reverse-order" strategy is used extensively in practice, it is not used universally. Specifically, reverse ranking may be used to a lesser extent when there is heterogeneity of preferences, when an unexpectedly important story occurs (unless the firm announces upfront that it will provide the story later in the rankings), or when readers have a strict preference for reading the most newsworthy stories first. In these cases, firms may rank newsworthy stories first, especially when skipping costs are sufficiently low, and reverse-ranking may be used over just a subset of stories. The reverse-ranking result is stronger with media with high skipping cost such as television or radio. We return to this when comparing equilibria across media types in Section 4.2.

Firm optimal ranking strategy. Given Proposition 6 and consistent with the examples of Section 3.2, the firm's optimal strategy takes the following simple form. Rank the stories of a topic that will be read by readers in "reverse order" from least to most newsworthy. Suppose, for ease of illustration, that there is just one topic, as in Proposition 4 and the very first example of Section 3.2. Then the algorithm consists of including the most important story of the topic ($s^k_{N_k}$ in general, s^A_3 in the mentioned example), preceded by the second most important story ($s^k_{N_k-1}$), and so on, until the reader cannot be induced to read one more story (in the mentioned example, the reader cannot be induced to read s^A_1). All remaining stories are then appended to the end, i.e., after story $s^k_{N_k}$, and will not be read in equilibrium.[17] When there are two topics, then the same method holds within each topic and again for stories that will be read.

News with suspense. In addition to the reverse-ranking result, there is a well-defined type of story composition that firms prefer, when time costs are high. These stories lend themselves to being displayed in a way that keeps readers waiting for the most interesting news items, and for the punch line or the resolution of the events. Media outlets can then keep readers in suspense until they read the most significant parts.

As an illustration, consider the example setup in Section 3.2 (utility $u_A(x) = x$ over topic A, and time cost function $c(\tau) = 4\tau^3$ with costs of reading and skipping $\nu_{RD} = 0.3$ and $\nu_{SK} = 0.05$, respectively). Compare the following two sets of stories, only on topic A: $S = \{s^A_1, s^A_2, s^A_3\}$ where $\lambda(s^A_1) = 1$, $\lambda(s^A_2) = 1$ and $\lambda(s^A_3) = 2.5$ and $\widetilde{S} = \{\tilde{s}^A_1, \tilde{s}^A_2, \tilde{s}^A_3\}$ where $\lambda(\tilde{s}^A_1) = \lambda(\tilde{s}^A_2) = \lambda(\tilde{s}^A_3) = 1.5$. Even though sets S and $\widetilde{S}$ are identical in terms of total newsworthiness, media firms do not view these states of the world as equivalent. They are not concerned with total newsworthiness, but with how much readership they can obtain. Sets S and $\widetilde{S}$ differ in that S is more "suspenseful" than $\widetilde{S}$. In $\widetilde{S}$, the three most newsworthy items are equally interesting, but in S, media firms can potentially keep readers waiting for the most interesting bit, or punch line, s^A_3, thereby inducing readers to read more stories. Specifically, in both S and $\widetilde{S}$, the reader only wishes to read two stories. But in S a firm can induce the reader to read three by ranking them in increasing order $\sigma = (s^A_1, s^A_2, s^A_3)$, while in $\widetilde{S}$, the firm cannot induce him to read more than two.

We can define a strict ordering over such stories that is similar in spirit to first-order stochastic dominance. Consider two sets of stories $S = \{s^k_1, ..., s^k_N\}$ and $\widetilde{S} = \{\tilde{s}^{\tilde{k}}_1, ..., \tilde{s}^{\tilde{k}}_N\}$, where S consists only of topic $k \in K$, and $\widetilde{S}$ only of topic $\widetilde{k} \in K$, (k and $\widetilde{k}$ need not be the same). Suppose again, for notational convenience, that the indices are ordered by increasing newsworthiness, $\lambda(s^k_1) \leq ... \leq \lambda(s^k_N)$ and $\lambda(\tilde{s}^{\tilde{k}}_1) \leq ... \leq \lambda(\tilde{s}^{\tilde{k}}_N)$. Since the two topics may be different, we compare the total newsworthiness

[17] Formally, if the reader can be induced to read m stories from topic k, then these m stories will be ranked $\{s^k_{N_k-m+1}, s^k_{N_k-m+1}, ..., s^k_{N_k}\}$, and all less newsworthy stories will be appended afterwards. The firm does not precede story $s^k_{N_k-m+1}$ with story $s^k_{N_k-m}$ because either the consumer would skip it, or he would not read up to story $s^k_{N_k}$, meaning that this strategy no longer increases readership.

using utility as a metric to allow for comparisons. Then, suppose that the total newsworthiness is the same in sets S and $\widetilde{S}$, which translates to having equal total *utility* of all stories, $u_k(\sum_{i=1}^N \lambda(s_i^k)) = u_{\widetilde{k}}(\sum_{i=1}^N \lambda(\tilde{s}_i^{\widetilde{k}}))$. This assumption is not necessary, but it guarantees that one set is not inherently more newsworthy than another. Then, if $u_k(\sum_{i=h}^N \lambda(s_i^k)) \geq u_{\widetilde{k}}(\sum_{i=h}^N \lambda(\tilde{s}_i^{\widetilde{k}}))$ for each index $h \in \{1, \dots, N\}$, we say that the set of stories S holds more **suspense potential** than $\widetilde{S}$ (written $S \succeq_{SP} \widetilde{S}$, where $\succeq_{SP}$ represents a partial order over sets of stories understood as states of the world).[18]

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

There are two dimensions to the notion of dominance by suspense potential ($\succeq_{SP}$). The first is that *within* a topic, one set of stories is constituted in a more suspenseful way than another. The second is that *across* topics, the *curvature* of the utility function also affects potential for suspense. The more convex the utility function, or the higher the curiosity preferences, the higher the suspense potential. The following result then holds (the more general result in which the state of the world need not consist of only one topic is deferred to Appendix B.7):

Proposition 7 (Suspense, readership and profitability). *Let $\Gamma(S)$ and $\Gamma(\widetilde{S})$ be games with state of the world S and $\widetilde{S}$ respectively, that are otherwise equal, with large switching costs $\nu_{SW} > \bar{\nu}_{SW}$, for some $\bar{\nu}_{SW} > 0$, and with $u_k''(\cdot) \geq 0$, for $k \in K$. If $S \succeq_{SP} \widetilde{S}$, then there exists $\overline{\nu}_{SK} \in [0, \nu_{RD}]$ such that firms can induce readers to read more stories and hence can make more profit in $\Gamma(S)$ than in $\Gamma(\widetilde{S})$, for all $\nu_{SK} \geq \overline{\nu}_{SK}$.*

In words, if skipping costs are not too small, then firms benefit from having more suspense potential. Intuitively, if firms know that readers will not skip, then firms can hold them in suspense and delay the more important stories for longer, providing more distractions until the punch line. Firms can then take advantage of states of the world with more suspense potential. Notice that, for high enough suspense potential, there may be *fewer* stories that readers would like to read since newsworthiness is more concentrated. But, with high enough skipping costs, firms can drive a larger wedge between what readers wish to read and what they do read, and even though their *desire* to read may diminish, the *amount* they read increases. If instead skipping costs are low, then higher suspense potential may *not* be beneficial, as readers may prefer to skip directly to the punch line. There can be, therefore, a significant difference in the order in which stories are presented between media platforms with high associated skipping costs and platforms with low associated skipping costs.

[18] The first condition that $u_k(\sum_{i=1}^N \lambda(s_i^k)) = u_{\widetilde{k}}(\sum_{i=1}^N \lambda(\tilde{s}_i^{\widetilde{k}}))$ is not required for our results and can be dropped; we mention it only for the total content of the sets of stories to be the same. The term "suspense" is also used, in a different manner and context, in Ely et al. (2015).

Since suspense potential contains dimensions of both news composition and preferences, this result has at least two implications. The first is in terms of preference for news arrival. To the extent that firms can impact news production, they would want to influence the way stories are packaged. This power of influence depends on the fundamental properties of the stories themselves and on the media firm's type; online news aggregators, for instance, have arguably little direct impact on news production. Second, unless skipping costs are very low, firms prefer stories from topics that induce high curiosity preferences (political scandals, entertainment and so forth). In particular, media platforms with high skipping costs, such as broadcast television, are more effective than those with smaller skipping costs at promoting topics with high suspense potential.

3.4 Heterogeneous Readers, Targeting and Advertising

Targeting, or the possibility of using consumer profile data to deliver individualized or "targeted" content as well as advertising, is a main innovation of the internet, distinguishing it from traditional media.[19] Although not yet fully developed, it can be viewed as a justification for the assumption of homogeneous readers made throughout the paper. Here, we consider the case of heterogeneous readers to point out some obvious qualifications of our main results, and we also briefly discuss advertising with time constrained readers.

Differentiation and non-reverse-rankings. In Section 3.2, mainly as a consequence of consumer homogeneity, profit-maximizing outlets coincide on their ranking of stories. With heterogeneous consumers, firms may differentiate their rankings, especially when they have limited ability to target their news coverage to individual readers. This can occur when readers have different preferences over topics. It can also contribute towards reducing the competition between outlets, because firms may then specialize in different topics, as is common in practice. Another type of heterogeneity, natural to our analysis, occurs when readers have different time costs. For instance, readers with busy work schedules might have relatively high time costs of consuming news; young and technologically savvy readers might have relatively low switching or "browsing" costs. Such heterogeneity can undo the reverse-ranking result of Section 3.3 by putting pressure on outlets to rank newsworthy stories more prominently in order not to lose heterogeneously time constrained readers.

Advertising Segments. Advertising can affect media consumption through the time costs that it imposes as well as through the screen space it takes away from news stories. For example, firms can introduce forced-view advertising through commercials that take the form of "stories" with a positive reading cost, but with near-zero newsworthiness, where, as is increasingly the case in online media, viewers are obliged to "see" them before advancing through the website. Our model can then be applied to analyze optimal placement of advertising and implications for the news ranking and consumption. Advertising can lead to extra time cost incurred by the readers but can also contribute

[19] See, e.g., Athey and Gans (2010), Athey et al. (2014); see also Pariser (2011).

to the crowding out of stories that are newsworthy. Since time costs and constraints vary with media type, our previous analysis suggests that optimal reporting and advertising strategies might vary across media types. We illustrate in Appendix A.1 how these different strategies arise, and show how firms can employ suspense, as formally defined in Section 3.3, to keep readers through an advertisement to see the end of a story.[20]

4 Applications and Further Results

We show in this section how our framework can be easily adapted to address different policy-relevant questions. We first analyze conditions under which public media and access fees can help restore reader efficiency. We then briefly discuss implications for news consumption of differences in costs of processing across news media platforms. Finally, we extend our model to allow for media bias and discuss political economy implications of our theory.

4.1 Restoring Reader Efficiency

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

Public media. The value of public media has been an intense subject of debate in recent years, even generating extensive attention during the 2012 US presidential campaign, and culminating in candidate Mitt Romney's well-publicized comment that he would stop government funding of the public broadcasting television network *PBS* (*Public Broadcasting Service*) if elected.[21] To study public media within the context of our model, we add a *public media firm* and assume that it maximizes the utility of the average viewer. In our application with homogeneous readers, it is immediate that the public outlet always directly chooses the reader-efficient ranking. More importantly, when such an outlet is present in the market with other firms and with low reader switching costs, then *all* equilbria

[20] The source of disutility or bias here is the time cost imposed by advertising with possible consequences for stories read (or *not* read). It is related to the two-sided market models in which advertising causes a general disutility of consuming media programs through its effects on firm revenues, as in Anderson and Coate (2005) and Wilbur (2008); but it is distinct from models in which advertising can distort the type and quality of reporting, such as George and Waldfogel (2003), Hamilton (2004), Ellman and Germano (2009) and Germano and Meier (2013). In a framework in which advertising can negatively influence media content, Kerkhof and Muenster (2015) show how caps on the quantity of advertising can be welfare-improving in a strong sense; our results complement this by showing that limiting the quantity of advertising can be beneficial in the sense of limiting the amount of crowding out of news stories that occurs due to advertising.

[21] His comment, frequently referred to as the "Big Bird" comment, has been widely covered and discussed; for instance, it is first on *Google*'s list of "trending" US political gaffes of 2012, and has led to a quarter million "Tweets" on *Twitter*.

are reader-efficient.[22]

Proposition 8 (Public media and reader efficiency). *For any given game* Γ*, where one of the media firms is a public one, there exists a* $\bar{\nu}_{SW} > 0$ *such that for any* $\nu_{SW} < \bar{\nu}_{SW}$*, every Nash equilibrium of* Γ *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 model with homogeneous readers. The presence of an easily accessible public outlet does not imply that it captures the market from other outlets. In equilibrium, no consumer switches outlet, even in the case of low or zero 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 adhere to.[23]

We emphasize, however, that public outlets in our setting, by assumption, maximize reader preferences. In practice, this may not always be the case, and the literature distinguishes among different ways in which public media are governed (Aalberg and Curran, 2011, and Cushion, 2012). In some cases, public media may place higher weight on public affairs than readers do, perhaps out of concern for social efficiency; in others, they may have very different incentives. Arguably, public media that are paid directly by the consumers or that are funded with public money enforce some degree of accountability towards consumer preferences.[24]

Prices and access fees. We now allow media firms charge a price that gives readers access to their websites. Introducing fees may change the ranking chosen towards a more reader-efficient one, depending on the relation of how much firms can charge consumers for giving access versus what they can get from advertisers for running advertisements.

Suppose that each firm $i \in I$ can charge a fixed access fee, $p^i \geq 0$, in stage 1 of the game, that allows readers to access i's website.[25] This adds a fixed (state-independent) viewer fee component – the sum of all fees received – to the firm's profit function in Section 2.3. The reader's expected utility function is as before, except that the fee p^i is now subtracted when the reader accesses firm i's website for the first time. Let σ^* and $\hat{\sigma}$ denote, respectively, the reader-efficient ranking and the ranking that a monopolist would choose in the standard model without prices, and let P^* and $\hat{P}$ be

[22]Recall that small switching costs do not, in general, guarantee reader-efficiency; Proposition 1 merely shows existence of a reader-efficient Nash equilibrium when switching costs are small.

[23]This role for public media is emphasized in Cushion (2012). The result seems consistent with recent comparative studies of media systems in advanced democracies, where a stronger presence and funding of public media is associated with a higher level of knowledge of the public, especially on public affairs issues; see Aalberg and Curran (2011) and Cushion (2012). The difference between the largely commercial US system and the European systems with important presence of public media seems to be particularly pronounced.

[24]Interestingly, public media in established democracies often have consistently high levels of public trust from the public; for instance, *BBC* news typically ranks at the top with an important margin in the UK (see www.pressgazette.co.uk/node/45249); *PBS*, despite its relatively smaller viewership, also ranks high in polls in the US (see www.pbs.org/about/news/archive/2013/pbs-most-trusted/); see also Ladd (2012) and Tsfati and Ariely (2014). However, caution should be exercised in interpreting these results without further empirical analysis on the underlying causality. Benson and Powers (2011) contains a comparative study of public media in 15 OECD countries.

[25]Formally, within the basic game Γ (or Γ_{ext}), the fee is added as a strategic variable to the firm's ranking σ^i.

the corresponding ex-ante plans of actions of the readers, leading to utilities $U_0(P^*|\sigma^*)$ and $U_0(\hat{P}|\hat{\sigma})$, respectively. Assume, for simplicity, that P^* and $\hat{P}$ involve different numbers of stories read.

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

(i) if the utility gain from reading stories is sufficiently large relative to the the price paid by advertisers, (the price per story read by a unit mass of readers is implicitly set to one in our baseline profit function from Section 2.3), then the optimal strategy is to choose the (reader-efficient) ranking σ^* and charge a fee of $p^* = U_0(P^*|\sigma^*)$;

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

In both cases, the firms appropriate all the consumer rent, and the difference lies in which ranking is provided to the viewers. Whether the firms choose the reader-efficient ranking (σ^*) or the monopoly ranking ($\hat{\sigma}$) in equilibrium depends on the relation between advertising revenue and the reader's added willingness to pay to read his most preferred stories.

The other extreme of zero switching costs ("perfect competition") also contains the two opposing cases. At the profit-maximizing equilibrium, in case (i), firms choose the reader-efficient ranking σ^*, and in case (ii), they choose the monopoly ranking $\hat{\sigma}$. The difference, however, is that they charge zero fees in both cases.[26]

4.2 Different Media Types and Platforms

The essential features of our model are that consumers do not see all the news at once, that they access rankings of stories provided by outlets through given menus of choices, and, when processing the news, readers incur reading, skipping and switching costs (see Dyson, 2004 for a survey of the literature on reading effectiveness and text configuration on screens). While we have focused on online newspapers, these attributes hold for most media types, including television, radio, print newspapers and magazines, but also for social media and digital platforms accessed through tablets and smartphones. Our framework applies to this wide array of media. In some cases, such as broadcast television and radio, the model can be adapted in a simple way. In our setting, the main differences between media types are captured by the magnitudes of the different costs of processing news.

[26]For brevity, we do not consider intermediate switching costs, which contain similar mechanisms. We also note that the cutoffs for cases (i) and (ii) may not be the same for the monopoly and perfect competition cases, as they depend on the switching costs. Hagiu and Jullien (2011, 2014), in different frameworks, also obtain that price fees may bring rankings closer to efficiency without necessarily achieving it.

Traditional media. While equilibria often avoid both skips and switches in the case of homogeneous readers (Proposition 3), this does not imply that corresponding costs are irrelevant. On the contrary, as illustrated in Section 3, the sizes of the readers' costs of processing the news as well as the shape of the time cost function are crucial in determining equilibrium rankings. Therefore, when comparing media, it is useful to focus on the comparative statics as both the processing costs and time constraints vary, while abstracting away from other existing differences.

Consider, for instance, broadcast television and radio. In both cases, while the switching costs may be relatively low, the skipping costs can be high, and may even approach the reading cost of viewing or sitting through a whole story. In Section 3, Proposition 4 and the subsequent examples show how the reading and skipping costs can determine the amount of extra stories read in equilibrium, and Proposition 5 shows how important stories can be crowded out. Proposition 7 implies that with high skipping costs firms have a greater ability to use the stories' suspense potential to increase stories read. At the same time, Proposition 1 shows that small skipping costs lead to reader efficient rankings. Consistent with these results, the subject of Anna Nicole Smith described in Section 3.2, which has clear suspense potential, has received significantly more coverage in the US cable television than in online news (22% compared to 4%; PEJ, 2007). As discussed above, it has also contributed to crowding out important news. Also, to the extent that the skipping costs are lower in online media, our findings may also explain part of the migration of viewers *away* from television and radio to online news consumption (see, e.g., Pew Research Center, 2012).[27]

Online aggregators. News aggregators have recently gained prominence in the online media market, and including them in our analysis seems worthwhile for understanding online news provision and consumption. Our basic framework can be viewed as a model between aggregators rather than between media outlets. The assumption that media outlets' strategy is reduced to one of ranking given stories is particularly natural for aggregators, as they have very low marginal cost of obtaining news stories. The main insights of our model, therefore, also hold in a setting with aggregators.[28] We note, however, that incentives of news aggregators may be different from those of news producers, which could impact their choice of rankings.

Social media. Social networks and forums, such as *Twitter*, *Facebook*, *Gawker*, and blogs in general, have risen in popularity as alternatives to traditional media. Accounting for their richness and the different aspects and alternatives that exist is outside the scope of this paper. Nonetheless, a number of these platforms maintain a degree of control over the manner in which news is displayed. *Facebook*, for instance, has a newsfeed which provides users with a ranking of postings. It also increasingly intersperses the newsfeed with advertisements, precisely in the manner discussed in Section 3.4. To the extent that their incentives may also be to keep consumers reading more "news" stories, similar

[27] An audience migration away from the traditional media may, over time, induce them to provide more reader-efficient rankings as well.

[28] Athey and Möbius (2012), George and Hogendorn (2012), Dellarocas et al. (2013) and Jeon and Nazr (2013) study aggregators in settings without time constraints.

tensions to the ones described here may persist. That is, the possible misalignment between ranking stories according to the consumers' preferences and keeping consumers connected longer would remain. Moreover, other platforms, including *Twitter*, also allow news producers (including *The New York Times* and *CNN*, among many others) to have accounts to which users can subscribe. The insights of our results then hold in these settings as well.[29]

4.3 Political Outcomes and Time-Constrained Voters

The results of Section 3 point to an important feature of the equilibrium rankings of our basic model, namely, that even a small direct utility difference compared to the reader-efficient ranking may be associated with a very different set of stories read. When story informativeness is introduced, this observation implies that readers may acquire very different information from what they would prefer. In particular, they may read more than they wish to, while being systematically *less* informed on relevant subjects. In a political economy setting with voting this may have significant consequences due to informational externalities.

So far, we have not assumed any political bias in our model, and it is not required for the notion that readers may be systematically uninformed on politically important topics. But, to better study possible effects of time constraints of news consumption on voting decisions, we now explicitly introduce story content and assume firms *are* politically biased.

Media bias. A large literature documents media bias and the degree to which, empirically, media firms systematically underreport or overreport on specific subjects (political or otherwise).[30] Throughout the paper, we have assumed away any biases on the part of both firms and readers. Allowing for bias, requires a simple change to the firms' profit function of Section 2.3. We extend it as follows:[31]

$$\Pi^i(\sigma^i|\sigma^{-i}) = \sum_{k\in K}\sum_{n\in S_k^i} \mu_n^{k,i}(\sigma^i,\sigma^{-i}) + \sum_{k\in K}\alpha_k^i \sum_{n\in S_k^i} \mu_n^{k,i}(\sigma^i,\sigma^{-i})\lambda_n^k z_n^k, , i\in I,$$

where now $z_n^k \in \{-1,0,1\}\times\mathbb{N}\times K$ keeps track of the **content** of a story that, for simplicity, takes three values: -1 for negative content, 0 for neutral content and $+1$ for positive content. Accordingly, $\alpha_k^i \in \mathbb{R}$ captures firm i's bias for readers viewing stories on topic $k\in K$ weighted by newsworthiness and content. Recall that $\mu_n^{k,i}(\sigma^i,\sigma^{-i})$ is the share of the readership that firm i receives on topic k, and λ_n^k is newsworthiness. Setting $\alpha_k^i \neq 0$ indicates that firm i cares about which newsworthy stories consumers read. Introducing uncertainty in the model (see Appendix A.2), this becomes a proxy for *information* received by the readers; a more newsworthy story is also more informative, and the content variable z_n^k refers to the intrinsic information transmitted to readers. Hence, $\alpha_k^i > 0$ for topic

[29]Hong (2012) studies the interplay of *Twitter* and mainstream news sites. Curran et al. (2012) and Lovink (2011) contain useful general analyses of social media; see also Pariser (2011).

[30]See Strömberg (2004) on political bias, Besley and Prat (2006) on government capture, Ellman and Germano (2009) on advertiser-driven bias, and Petrova (2012) on media capture by special interest groups. Blasco and Sobbrio (2012), Prat and Strömberg (2013) and Sobbrio (2014b) contain recent surveys.

[31]See Ellman and Germano (2009) or Anderson and McLaren (2012) for microfoundations of related profit functions.

k captures bias for content in one direction (in favor of positive news content on topic k), and $\alpha_k^i < 0$ captures a preference for content in the opposite direction. This model therefore allows for political (or other) biased preferences by the firm. Note that, as in the rest of the model, the firms' strategies consist only of ranking the stories; we have not extended the model to allow for *slanting* the content of stories.[32] It is straightforward, then, to show that such preferences will influence the ranking of the stories as firms seek to emphasize or suppress information on specific issues. Maintaining the assumption that consumers are aware of this process and of firms' preferences, and that they are fully Bayesian rational, consumers still may not receive the stories and hence the information that they would like. Their posterior beliefs may be affected, even when they account for the firms' strategies.

Preference over media outlets. Consumers often prefer to read from outlets that share their views. For instance, Gentzkow and Shapiro (2010), in their empirical analysis of media slant, find strong evidence that readers have a preference for like-minded news. From an informational viewpoint, this preference has been viewed as puzzling, as it appears that readers have more to learn from reading news that does more than confirm their prior. Models have been developed to better understand these preferences, and have yielded valuable insight.[33]

Our model provides a novel and intuitive explanation for readers to have a preference for like-minded outlets. Suppose that there is more than one firm to choose from, and that viewers do not have high switching costs. Moreover, suppose that readers have heterogeneous informational priors, once uncertainty is introduced (see Appendix A.2), then, whether or not there is also supply-driven heterogeneity in biases, the market outcome may be one of differentiation, as discussed in Section 3.4.[34] Readers will then have a preference to read from the firm whose editorial policy is *closest* to their prior, as they believe that this firm will be more likely to rank on top (or less likely to "conceal") information that is relevant for them. In other words, readers here self-select to acquire news from outlets that "share" their views not because they have a preference for information that supports their beliefs, but rather because they can more easily *access* stories of interest.

5 Closing Remarks

The market for news is increasingly dominated by digital and online media that offer readers access to overwhelming amounts of information through extraordinarily flexible menus of options. To study

[32]Additional factors can be included in the firms' profit function, such as a preference for readership of specific topics. For instance, viewers may be more receptive to advertisements when viewing sports news. This can be done by multiplying the first term of the profit function by a parameter β_k^i, thus weighting readership according to the topic.

[33]See, e.g., Mullainathan and Shleifer (2005), Gentzkow and Shapiro (2006), Chan and Suen (2008), Sobbrio, (2014a) and Piolatto and Schuett (2015).

[34]A recent article in *The New Yorker* remarks: "MSNBC and Fox News often express their differing political priorities by covering different stories: Fox viewers, for instance, have learned an awful lot about the exploits of the New Black Panther Party, while MSNBC viewers were treated to a series of concerned segments about that Cheerios commercial, including an interview with one of the actors,"(*The New Yorker*, September 2013). Related to this point, Schroeder and Stone (2015) find that viewers of *Fox News* in the US are not less informed overall than average viewers, but appear to be better informed on topics favorable to Republicans.

this market, we have developed a framework in which media firms rank stories in any state of the world and in which consumers can browse through the menus of choices offered by the firms. This provides a unifying framework that accommodates diverse types of new and traditional media, and that captures differences between media types through the time costs of accessing and processing the news offered. We find that, although small when taken individually, these costs, together with the preferences and time constraints of individuals can play a crucial role in determining overall equilibrium news market behavior.

Consumers may end up spending significantly more time consuming news than they would prefer to. Moreover, because news items are typically drawn from multiple topics, they may also consume substantially different sets of stories than their most preferred ones. In particular, we find that there is an inherent fragility in which news is covered prominently and ultimately consumed. This can have serious implications for the degree of information of individuals. We also provide conditions under which firms can keep readers reading more stories or viewing more advertisements, and also conditions under which important stories are crowded out. We find that, besides the costs of processing the news, the crucial factors include the shapes of individuals' time cost and utility functions, as well as the suspense potential of the stories available. The main insights of the theory readily apply to various domains even outside pure news media, such as social media and online product search.

The framework also naturally lends itself to the analysis of political economy settings in which interactions between the news media and time-constrained voters involve important informational externalities. Our model then provides a tractable tool for more extensive theoretical and empirical investigations of the media market and its political economy ramifications. Measuring the costs and preferences involved in news consumption, and relating these to the actual news offered and consumed, would serve to evaluate our results and further shed light on the welfare consequences of a rapidly changing media environment.

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Appendix

A Extensions

We elaborate here on two particularly important extensions of the basic model that have only been briefly alluded to in the text, namely, allowing media firms to display advertising segments, and introducing uncertainty about the state of the world for readers.

A.1 Advertising

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

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

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

$$S = \left\{s_1^A, s_2^A, s_3^A, s_4^A\right\},$$

where all stories have equal newsworthiness, $\lambda(s_1^A) = \ldots = \lambda(s_4^A) = 3$, so that the ranking is of no importance. Without advertising, the consumer reads four stories and receives utility 6.82.[35] With advertising, the firm chooses strategy

$$\sigma = (\boldsymbol{AD}, \boldsymbol{s_1^A}, \boldsymbol{AD}, \boldsymbol{s_2^A}, s_3^A, s_4^A),$$

where AD refers to the placement of an advertising segment. The consumer now reads three stories and views two advertisements. It is clear that the firm will place an advertising segment at the very beginning, as is commonly observed on websites. It then reduces the number of advertisements as the reader goes further down the ranking. It cannot place an advertisement before the third story, as the reader would then choose to stop reading after only two stories.

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

$$\widetilde{S} = \left\{s_1^B, s_2^B, s_3^B, s_4^B\right\},$$

[35] To be fully consistent with our assumption, the state of the world would include more stories than the consumer would read; we omit these for simplicity.

where now $\lambda(s_1^B) = \lambda(s_2^B) = 0.5$ and $\lambda(s_3^B) = \lambda(s_4^B) = 0.7$ and so is made up of only complementary stories on topic B. Without advertising, the consumer reads four stories, as in state S. He receives utility 6.34, which is *less* than he would have received in state S when there is no advertising. Nevertheless, the firm can still make *more* advertising revenue in state $\widetilde{S}$. The firm's strategy is now

$$\widetilde{\sigma} = (\boldsymbol{AD}, \boldsymbol{s_1^B}, \boldsymbol{AD}, \boldsymbol{s_2^B}, \boldsymbol{AD}, \boldsymbol{s_3^B}, s_4^B),$$

and the consumer reads three stories and views *three* advertisements. The firm still places an advertisement at the very beginning, but now it can also place an advertisement near the end of the relevant ranking, i.e., before the last story read. From a welfare perspective, when advertisements *are* allowed, the reader obtains less utility in $\widetilde{S}$ than in S.

Advertising and Suspense. The firm makes more profit in state $\widetilde{S}$ than in state S, as it can obtain more advertising revenues, despite the reader's utility over the stories read, net of advertising, being smaller. It is then immediate that in a state of the world in which the firm has a choice between stories from both topics, it would prefer to display stories on topic B and make more advertising revenue, even when the total number of stories consumed is the same for both topics. Firms effectively employ suspense, as formally defined in Section 3.3, to keep readers through an advertisement to see the end of a story. This result is general. Specifically: *if a set of story $\widetilde{S}$ holds more suspense potential than a set of story S ($\widetilde{S} \succeq_{SP} S$), then, for high enough skipping and switching costs, the firm places (weakly) more advertisements and makes (weakly) more profit.*

Time Constraints and Advertising. It has been claimed that less time-constrained readers are more valuable to advertisers. To see this, consider the effect on advertising of different time constraints, captured through changes in the time cost parameter d (recall that $c(\tau) = d\tau^3$). As d increases, readers are *more* time-constrained and indeed the firm places *fewer* advertisements. For instance, if $d = 4$, then the firm's strategy in state of the world $\widetilde{S}$ is given by $\widetilde{\sigma}' = (\boldsymbol{AD}, \boldsymbol{s_1^B}, \boldsymbol{AD}, \boldsymbol{s_2^B}, \boldsymbol{s_3^B}, s_4^B)$. The consumer then reads three stories and views only two advertisements. The result that in equilibrium the reader views fewer advertisements as his time constraint increases is robust.[36]

A.2 Uncertainty

Throughout the paper, we have assumed one state of the world for the sake of exposition. In practice, however, readers do not usually know what the state of the world is, but rather learn it through reading the news. We here extend the model to allow for uncertainty in the state of the world, and show that it can be beneficial to firms, as it provides them with an additional tool for attracting more readership. They can entice consumers to read stories that they would otherwise avoid. Uncertainty can therefore exacerbate the reader inefficiencies of Section 3.

Consider a more general framework, where, on a given day, the true state of the world ω can be identified with a realization of a set of stories, $S(\omega) = S_A(\omega) \cup S_B(\omega)$, on topics A and B with corresponding levels of newsworthiness λ just as before. The space of all possible states of the world can then be identified with a list of possible sets of stories $\mathcal{S} = \{S(\omega) : \omega \in \Omega\}$. Assume the number of possible stories and states, and hence

[36] Within the example in Section 3.2, we can show that *increasing* the reading cost ν_{RD} can sometimes make readers strictly better off. The reading cost reflects several aspects of reading the news, including the technological sophistication of the layout and ease of processing stories; it can also reflect the size of the screen of the device used (desktop, laptop, tablet, smartphone and so forth). Thus decreasing the reading cost need not be beneficial to readers.

$\mathcal{S}$, to be finite. There is a prior over the states of the world (formally, $\pi \in \Delta(\Omega)$), which we assume to be commonly known.

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

The timing of the game is as before with the Stage 1 replaced by the following:

Stage 1.1 The media outlets simultaneously choose rankings $\left(\sigma^i(S(\omega))\right)_{i \in I}$ of the stories for every state of the world $\omega \in \Omega$. These rankings (editorial policies) are known to all parties.

Stage 1.2 Nature draws the state of the world $\omega \in \Omega$ according to the prior π. The state is known to firms but not to consumers.

This leads to an extensive-form game of incomplete and imperfect information Γ_{ext} between media outlets and readers. Given media outlets' strategies in Stage 1.1 and given that consumers are individually negligible and independent of each other, consumers' expected demand continues to be well-specified and straightforward to derive. The game Γ_{ext} can again be reduced to a normal form game Γ between just the media outlets as before; again, a Nash equilibrium always exists.

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

$$
\begin{aligned}
S_1 &= \left\{s^A_{1,1}, s^A_{1,2}, s^B_{1,1}, s^B_{1,2}, s^B_{1,3}\right\} \text{ with } \lambda(s^A_{1,1}) = 2, \lambda(s^A_{1,2}) = 1.2, \lambda(s^B_{1,1}) = 0.7, \lambda(s^B_{1,2}) = 0.45, \lambda(s^B_{1,1}) = 0.3,\\
S_2 &= \left\{s^A_{2,1}, s^A_{2,2}, s^B_{2,1}, s^B_{2,2}, s^B_{2,3}\right\} \text{ with } \lambda(s^A_{2,1}) = 2, \lambda(s^A_{2,2}) = 1.2, \lambda(s^B_{2,1}) = 1, \lambda(s^B_{2,2}) = 0.45, \lambda(s^B_{2,1}) = 0.3,
\end{aligned}
$$

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

$$
\sigma^*(S) = \begin{cases} (\boldsymbol{s^A_{1,1}}, \boldsymbol{s^A_{1,2}}, s^B_{1,1}, s^B_{1,2}, s^B_{1,3}) & \text{if } S = S_1 \\ (\boldsymbol{s^B_{1,1}}, \boldsymbol{s^B_{1,2}}, s^B_{1,3}, s^A_{1,1}, s^A_{1,2}) & \text{if } S = S_2\,, \end{cases}
$$

according to which a consumer reads $s^A_{1,1}$, $s^A_{1,2}$ in state S_1 and $s^B_{2,1}, s^B_{2,2}$ in S_2.

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

$$
\widetilde{\sigma}(S) = \begin{cases} (\boldsymbol{s^B_{1,3}}, \boldsymbol{s^B_{1,2}}, \boldsymbol{s^B_{1,1}}, s^A_{1,1}, s^A_{1,2}) & \text{if } S = S_1 \\ (\boldsymbol{s^B_{2,3}}, \boldsymbol{s^B_{2,2}}, \boldsymbol{s^B_{2,1}}, s^A_{2,1}, s^A_{2,2}) & \text{if } S = S_2. \end{cases}
$$

In equilibrium, the reader considers only two options that are not strictly dominated, namely, (i) to read all three stories, regardless of the state, and (ii) not to read any story at all.[37] He maximizes expected utility $E[u_A(R^A) + u_B(R^B) - c(\tau)]$. (Recall that from Section 2.4, it suffices to consider the ex-ante stage, since the agent is dynamically consistent and does not deviate in future periods from his plan of action.) It is straightforward to show that there is a threshold $\hat{p}$ (more precisely, $\hat{p} \approx 0.91$) such that, for $p < \hat{p}$, the reader will read all three stories of topic B in *both* states of the world (in which case, $\sigma_1 = \sigma_2 = \widetilde{\sigma}(S)$ is an equilibrium). This holds even though the readers will receive strictly negative ex-post utility in state 1, implying that they would have preferred not reading any story. This result confirms the intuition that, if media markets do not deliver the reader-efficient ranking when there is just a single state of the world, then a similar, and perhaps more pronounced, implication holds with uncertainty as well. (This is consistent with results from the empirical search literature, e.g., Jeziorski and Segal, 2015.) It is also not difficult to show that the "best for last" result may not hold, for example, if there is a "breaking news" item, in which case the firms must signal to the readers that this news item has taken place by ranking it first. If, however, firms can announce at the beginning that there is breaking news, and defer the actual story to later in the ranking, then the "best for last" result may be restored to some extent. This is common practice in some television news shows, which have high associated skipping costs.

B Proofs

B.1 Dynamic Consistency and Ex Ante Utility Maximization

To show that the two interpretations mentioned in Section 2.4 are behaviorally equivalent, we first note that the agent is dynamically consistent: if, ex-ante, he intends to take a specific action at a future given history, then he does not change his mind if he reaches that node.

Lemma 1 (**Dynamic consistency**). *Suppose that at time t, the agent's period t utility maximization choice consists of taking action $a_{t'}$ at future history $H_{t'}$, where $t' \geq t$. Then, at time t' and history $H_{t'}$, the agent period t' maximization choice also consists of taking action $a_{t'}$.*

Proof. The proof is immediate. Consider any period t. The agent maximizes:

$$\begin{aligned} U_t(a_t|s_n^k, H_{t-1}, \sigma) &= \sum_{k\in K} \triangle u_k(x_t^k, x_{t-1}^k) - \triangle c(\tau_t, \tau_{t-1}) + EU_{t+1}\left(a_{t+1}|H_t, \sigma\right) \\ &= \sum_{k\in K} \triangle u_k(x_t^k, x_{t-1}^k) - \triangle c(\tau_t, \tau_{t-1}) + \sum_{H_t} p(H_t|H_{t-1}, \sigma) U_{t+1}\left(a_{t+1}|H_t, \sigma\right). \end{aligned} \tag{3}$$

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

$$U_{t+1}(a_{t+1}|s_n^k, H_t, \sigma) = \sum_{k\in K} \triangle u_k(x_{t+1}^k, x_t^k) - \triangle c(\tau_{t+1}, \tau_t) + EU_{t+2}\left(a_{t+2}|H_{t+1}, \sigma\right) \tag{4}$$

is unaltered from (3), and therefore that the maximizing choice is identical. Proceeding inductively, this holds for any history $H_{t'}$, where $t' \geq t$. □

[37] Not reading any story yields zero utility, which is preferred, in state S_1, to reading the stories in the given the order in which they are presented. Recall that we are assuming a high skipping cost (i.e., $\nu_{SK} \to \nu_{RD}$).

Even in the case in which the agent's choice to read an article on a given topic k increases his marginal utility of reading more stories on this topic ($u'_k > 0$), he is fully aware of this beforehand. He does not become "addicted" in a way that he had not anticipated. Since the agent is temporally consistent, it suffices to consider his expected utility in the ex-ante stage, as he will not deviate from his plan of action. Therefore, as a second interpretation, we can also think of the agent as simply maximizing his ex-ante expected utility.

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

Proof. 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:

$$
\begin{aligned}
U_0(P_0|\sigma) &= EU_1(a_{t+1}|H_t,\sigma) = \sum_{k\in K} \triangle u_k(x_1^k, x_0^k) - \triangle c(\tau_1,\tau_0) + EU_2(a_{t+1}|H_t,\sigma) \\
&= \sum_{t\in\{1..T\}} \sum_{k\in K} p_0(H_T|P_0,\sigma)\Bigg(\big((u_k(x_T^k) - u_k(x_{T-1}^k)) - (c(\tau_T) - c(\tau_{T-1}))\big) \\
&\qquad\qquad + \ldots + \big((u_k(x_1^k) - u_k(x_0^k)) - (c(\tau_1) - c(\tau_0))\big)\Bigg) \\
&= \sum_{t\in\{1..T\}} \sum_{k\in K} p_0(H_T|P_0,\sigma)\Bigg((u_k(x_T^k) + \big(u_k(x_{T-1}^k)) - u_k(x_{T-1}^k)\big) + \ldots + \big(u_k(x_0^k)) - u_k(x_0^k)\big) \\
&\qquad\qquad + c(\tau_T) + (c(\tau_{T-1}) - c(\tau_{T-1})) + \ldots + (c(\tau_0) - c(\tau_0))\Bigg) \\
&= \sum_{k\in K} p_0(H_T|P_0,\sigma)[u_k(x_T^k) - c(\tau_T)],
\end{aligned}
$$

which completes the proof. □

B.2 Reader Demand and Existence of a Nash Equilibrium

The following lemma allows to reduce the original extensive form game Γ_{ext} to a standard finite normal form game Γ. This readily implies existence of a Nash equilibrium.

Lemma 3 (Reader demand). *Let $\sigma = (\sigma^i)_{i\in I}$ be a strategy profile of firm rankings in stage 1; then there exists a function, $\mu_n^{k,i}$, that associates to each such profile the expected mass of readers going to an outlet i on given story s_n^k of any given topic k, $n \in \mathbb{N}, k \in K$.*

Proof. Fix a strategy profile of stage 1, $\sigma = (\sigma^i)_{i\in I}$, then the continuation game can be viewed as a separate and independent decision problem for each individual. Although the continuation game is, strictly speaking, of imperfect and incomplete information (as consumers do not necessarily know the state of the world, or what other consumers are choosing), because the consumers' payoffs are independent of each others' strategies, the subgame starting after the media firms' strategy choices can be viewed as consisting of separate decision trees that can be solved independently from one another. Furthermore, when costs are positive, $\nu_{SK}, \nu_{SW}, \nu_{RD} > 0$, (recall, that by assumption, $\nu_{RD} > 0$), finiteness of the number of states, the number of stories in each possible state, and the number of actions at any choice node, and the fact that all individuals are Bayes rational with a common prior over the possible states of the world, and have strictly increasing time costs $c(\cdot)$, insures that each decision tree is finite with an initial move by nature determining the state of the world. Hence it is solvable by backward induction. When costs can be zero, then consumers can in principle choose infinite sequences of, e.g., skipping stories or switching outlets (by assumption, $c(N\nu_{RD}) > \sum_{k\in K} u_k \left(\sum_{s^k\in S} \lambda(s^k)\right)$, for any $S \in \mathcal{S}$, so that readers will always only read a finite number of stories). However, it is easy to see that once the readers have identified the state of the world, then there is no gain in further skipping and switching beyond that of reaching the stories that it is optimal to read. But this requires only finitely many skips and switches and so is solvable by backward induction, for general $0 \leq \nu_{SK} \leq \nu_{RD}, 0 \leq \nu_{SW}$. The corresponding solutions obtained (restricting to ones with no "redundant" skips or switches if necessary) yield a compact and convex set of the possible expected mass of readers, for each possible strategy profile of stage 0, for which a selection with the desired properties always exists. □

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

B.3 Proof of Propositions 1 and 2

Given the discussion in the text, it is easy to see that reader-eficiency obtains when the skipping cost ν_{SK} is sufficiently small. We therefore focus on the case with small switching cost ν_{SW}.

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

Next we show the welfare implications for firms and readers as the switching and skipping costs vary. Fix $\nu_{SW} \geq 0$ and consider a Nash equilibrium profile that maximizes firms' expected profits. As we assume there are no switches in equilibrium, we can assume without loss that the equilibrium is symmetric (see Proposition 3). Let σ be the firms' ranking at ν_{SW}. Suppose now that ν_{SW} increases to ν'_{SW}. Then, if σ is not an equilibrium at ν'_{SW}, a firm has an incentive to deviate to another strategy, say σ'. At σ', the firm must have the same readers (the ones bookmarked with it) but they read more stories. (For, if a profitable deviation existed at which it attracted more readers, it would have been a valid deviation to σ at the original ν_{SW}, which violates σ being a Nash equilibrium at ν_{SW}.) Hence, if the deviation σ' 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 σ' at ν'_{SW} this constitutes a Nash equilibrium, which, moreover, gives both firms a strictly higher payoff. This shows that firms are weakly better off with increasing switching cost. To see that readers are weakly worse off with increasing switching cost, it suffices to note that if at σ' and ν'_{SW} the readers are (also) strictly better off, then again σ' would also have been a valid deviation at the lower cost ν_{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. Finally, the two results clearly also hold relative to the skipping cost ν_{SK}. To see this, simply replace skipping costs ν_{SK}, ν'_{SK} with corresponding switching costs ν_{SW}, ν'_{SW} in the above arguments of the above paragraph and the same conclusions hold. This completes the proof.

B.4 Proof of Proposition 3

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

Case 1: Reader 1 does not switch to outlet 2, while reader 2 switches to outlet 1 (there is at least one switch). Then outlet 2 has an obvious deviation which is to take the history H_2 of reader 2 and offer as a ranking the one associated to H_2.[38] In this case, reader 2 will not want to switch to outlet 1, and outlet 2 can have reader 2 reading strictly more stories on its outlet (with no fewer stories read by readers from outlet 1).

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

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

Next, starting from such a pure equilibrium $\sigma = (\sigma_1, \sigma_2)$ with no switches, it is easy to see that both symmetric profiles (σ_1, σ_1) and (σ_2, σ_2) also constitute equilibria. All profiles yield the same payoffs per reader to the firms. Fix the symmetric one that gives readers the highest utility, and call it σ'. Next, remove all stories skipped and append them in the same order of occurrence right after the last story read (under σ'). The resulting ranking σ'' has the readers reading the same stories as in σ' but now avoiding all skips. To see this, note that moving skipped stories down the ranking cannot lead to more stories being read since this would violate the property of σ or σ' being a Nash equilibrium (since the firms could have deviated at no cost to a ranking with more stories read; notice that stories skipped do not constitute any revenue for the firms). Moreover, because the stories skipped show up right after the stories read in the new ranking σ'', the reader also cannot benefit from reading fewer stories since he could also have done so earlier. Thus, σ'' is a pure symmetric Nash equilibrium without skips and without switches. Finally, since the same stories are read with σ'' as with σ', and readers do not have to skip stories with σ'', it is a weak Pareto improvement over σ' (and hence also over σ).

B.5 Proof of Propositions 4 and 5

To prove Proposition 4, suppose $u_A(x) = x$ and $c(\tau) = \tau$, and suppose there is a monopoly outlet, (ν_{SW} is sufficiently high). Then for a story to be inserted before a story of maximum newsworthiness $\lambda(s^A_{max}) = \lambda^A_{max}$ and b read, it must be the case that the utility from the reading the story and then reading the most newsworthy

[38]By this, we mean taking the history H_2 and extracting all the stories read or skipped and ranking them in the same order of occurrence as in H_2, and appending all other stories unread, afterwards, as they are ranked in the outlet where reader 2 stops reading. The same can be done for H_1.

one exceeds the utility from skipping it and only reading the most newsworthy story,

$$
\begin{aligned}
& u_A(\lambda(s^A_{max}) + \lambda(s^A_{extra})) - c(2\nu_{RD}) \geq u_A(\lambda(s^A_{max})) - c(\nu_{RD} + \nu_{SK}) \\
\iff \quad & \lambda^A_{max} + \lambda(s^A_{extra}) - 2\nu_{RD} \geq \lambda^A_{max} - \nu_{RD} - \nu_{SK} \\
\iff \quad & \lambda(s^A_{extra}) \geq \nu_{RD} - \nu_{SK}.
\end{aligned}
$$

Similarly, to see the maximum amount of stories of newswothiness $\nu_{RD} - \nu_{SK}(> 0$, and where $\nu_{SK} > 0)$ that can be inserted before a story of maximum newsworthiness s^A_{max}, compute the integer L such that

$$
\begin{aligned}
& u_A(\lambda(s^A_{max}) + L \cdot \lambda(s^A_{extra})) - c((L+1)\nu_{RD}) \geq 0 \\
\iff \quad & \lambda^A_{max} + L \cdot (\nu_{RD} - \nu_{SK}) - (L+1)\nu_{RD} \geq 0 \\
\iff \quad & L \leq \frac{\lambda^A_{max} - \nu_{RD}}{\nu_{SK}}.
\end{aligned}
$$

To prove Proposition 5, suppose to the contrary that $c(\cdot)$ is everywhere weakly concave. It suffices to check the case of a monopoly outlet (ν_{SW} sufficiently high). If s^A_{max} is read in equilibrium, it must be that $u_A(\lambda(s^A_{max})) \geq c(\nu_{RD})$. But then, no matter what story is inserted before s^A_{max} in the ranking, the following will always be satisfied $u_A(\lambda(s^A_{max})) \geq c(\nu_{RD})$, so that s^A_{max} will always be read and hence cannot get crowded out. This shows that a cost function cannot be weakly concave on all its domain to have crowding out of a story of maximal newsworthiness. Now suppose that $u_B(\cdot)$ is weakly concave on all its domain. Then, if story s^A_{max} is read in the reader-efficient ranking σ^*, we claim that if there is a ranking σ that crowds out s^A_{max}, then there must exist a payoff-equivalent ranking for the firm, where s^A_{max} is not crowded out. To see this, take the same ranking σ and replace the least newsworthy story read on topic A or B with the story s^A_{max}. This will not induce the reader to read less and cannot therefore give the media firm a lower profit. Hence it is a payoff-equivalent ranking to σ that does not crowd out s^A_{max}.

B.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 σ that maximizes the expected number of stories read by its readers in any state.

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

We now show that the stories read on any given topic can be replaced with the most newsworthy ones on that topic (always listed in increasing order of newsworthiness). Suppose for notational convenience that, for each topic k, stories are labeled such that $\lambda(s^k_1) \leq \lambda(s^k_2) \leq \ldots \leq \lambda(s^k_{N_k})$, where N_k is the total number of stories on topic k. Consider σ, where the m_k stories read on topic k are given by, say, $s^k_{1_\sigma}, s^k_{2_\sigma}, \ldots, s^k_{m_{k,\sigma}}$, where $1_\sigma < 2_\sigma < \ldots < m_{k,\sigma}$ so that $\lambda(s^k_{1_\sigma}) \leq \lambda(s^k_{2_\sigma}) \leq \ldots \leq \lambda(s^k_{m_{k,\sigma}})$. We need to show that we can replace σ with $\hat{\sigma}$, where the stories $s_{1_\sigma}, s_{2_\sigma}, \ldots, s_{m_{k,\sigma}}$ are replaced with the stories $s^k_{N_k - m_k + 1}, s^k_{N_k - m_k + 2}, \ldots, s^k_{N_k}$ respectively, such that $\hat{\sigma}$ is a an equilibrium ranking. Consider the following stepwise replacement scheme. Start with σ and replace story $s^k_{m_{k,\sigma}}$ with $s^k_{N_k}$. Next replace story $s^k_{m_k - 1,\sigma}$ with story $s^k_{N_k - 1}$, and so on, until story $s^k_{1_\sigma}$ is replaced with $s^k_{N_k - m_k + 1}$. We need to show that that the latter ranking $\hat{\sigma}$ yields profits at least as great as σ. This occurs if, under $\hat{\sigma}$, the reader still wants to read all m_k stories on each topic k, that is, she has no incentive to stop reading before having read all stories, and has no incentive to skip any story, whether or not on topic k. We show this for each replacement step. Consider the first replacement. To see that the reader has no incentive to stop reading before having read all stories, notice that, in any period (up to $\sum_k m_k$), the reader will continue reading since the benefits from continuing are at least as great as before the replacement and never smaller, whereas the time costs of continuing are unchanged. Similarly, to see that the reader also does not want to skip a story on topic k or k', notice that the least newsworthy stories, which the reader may want to skip (and which were being read under σ), again increase or stay equal in value added (since $u''_k(\cdot) \geq 0$), so that, in any period, the continuation utility of reading a story compared to skipping it cannot be less after the replacement than in the original ranking. For, it can be checked that, if the stories were not skipped under σ, then neither will they be be skipped after the replacement. The same arguments carry over at each replacement step (comparing it to the previous one) until the last replacement. Hence, the strategy σ' is optimal for firms, and readers are at least as well off as with σ. Lastly, we note that it must be that the same number of stories are read in σ' than in σ, because if more stories were read in σ' then σ could not have been an optimal strategy for the firms.

(b): To see 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 not all ordered in increasing order– it suffices to consider an example with two stories, namely, with a more and a less newsworthy one. The reader is willing to read the more newsworthy one after the lesser one but not vice versa.

B.7 Proof of Proposition 7

We first define suspense potential in a setting when the state of the world consists of more than one topic. Let $S = \{(\lambda^A_1, z^A_1), ..., (\lambda^A_{N_A}, z^A_{N_A}), (\lambda^B_1, z^B_1), ..., (\lambda^B_{N_B}, z^B_{N_B})\}$ and $\widetilde{S} = \{(\widetilde{\lambda}^A_1, \widetilde{z}^A_1), ..., (\widetilde{\lambda}^A_{N_A}, \widetilde{z}^A_{N_A}), (\widetilde{\lambda}^B_1, \widetilde{z}^B_1), ..., (\widetilde{\lambda}^B_{N_B}, \widetilde{z}^B_{N_B})\}$, where $N_A, N_B \in \{1, ..., N-1\}$. For convenience, the indices are ordered by increasing newsworthiness within the topic, $\lambda^k_1 \leq ... \leq \lambda^k_{N_k}$ and $\widetilde{\lambda}^k_1 \leq ... \leq \widetilde{\lambda}^k_{N_k}$, for $k \in \{A, B\}$. If $\sum_{i=h}^{N_k} \lambda^k_i \geq \sum_{i=h}^{N_k} \widetilde{\lambda}^k_i$ for each index $h \in \{1, \ldots, N_k\}$ and $k \in \{A, B\}$, we say that the set of stories S holds more **suspense potential** than $\widetilde{S}$ (written $S \succeq_{SP} \widetilde{S}$). When there is only one topic in each state (which need not be the same topic across states), define suspense potential as in the text, i.e. $u_k(\sum_{i=h}^N \lambda^k_i) \geq u_{\widetilde{k}}(\sum_{i=h}^N \widetilde{\lambda}^{\widetilde{k}}_i)$ for each index $h \in \{1, \ldots, N\}$. (The utility function is only required as a metric in the case of one state of the world when comparing across topics.) Note that one topic (or a selection of stories) can be the same in both states S and $\widetilde{S}$, so that we can define, in a natural way, suspense potential for only a set of stories. Note also that, while we do not require that the total newsworthiness is the same (in total or within a topic), we allow it, as would be desirable when comparing suspense potential over sets of stories that have equal total content. The statement of Proposition 7, which we prove below, is then identical to that in the main text.

Proof. Let $S \succeq_{SP} \widetilde{S}$, where $S = \{(\lambda^A_1, z^A_1), ..., (\lambda^A_{N_A}, z^A_{N_A}), (\lambda^B_1, z^B_1), ..., (\lambda^B_{N_B}, z^B_{N_B})\}$ and $\widetilde{S} = \{(\widetilde{\lambda}^A_1, \widetilde{z}^A_1), ..., (\widetilde{\lambda}^A_{N_A}, \widetilde{z}^A_{N_A}), (\widetilde{\lambda}^B_1, \widetilde{z}^B_1), ..., (\widetilde{\lambda}^B_{N_B}, \widetilde{z}^B_{N_B})\}$. Let ν_{SW} be prohibitively large, and consider the limit of $\nu_{SK} = \nu_{RD}$.

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

B.8 Proof of Proposition 8

By continuity of readers' cost and utility functions, it suffices to show the case $\nu_{SW} = 0$. Suppose that there are two outlets of which one is public and the other is a standard outlet with expected profits, as defined in Section 2.3. By assumption, the public outlet has a dominant strategy to choose a reader-efficient ranking. With $\nu_{SW} = 0$, the other outlet can retain its bookmarked audience only if it also offers a reader-efficient ranking (it cannot take audience away from the public outlet). This constitutes a Nash equilibrium, as both firms retain their audience and cannot improve their payoff by deviating.