Time Scarcity and the Market for News*

Larbi Alaoui† and Fabrizio Germano‡

April 19, 2019

Abstract

We develop a theory of news coverage in environments of information abundance. Time-constrained consumers browse through news items across competing outlets. They choose which outlets to access and which stories to read or skip, thus indirectly deciding how much time to spend on a given outlet. Firms decide on rankings of news items that maximize their profits. We show that even when readers (or television viewers) and firms are rational and unbiased, they spend more time on the news than they would like and not necessarily on the topics they prefer. In particular, relevant news items may be crowded out. We then study how reader-efficient standards can be restored and derive implications on diverse aspects of current media, including advertising and reader preference for like-minded news.

Keywords: Media markets; ranking news items; time-constrained consumers; digital media; news coverage; political economy.

JEL Classification: D43; H44; L13; L82; L86.

*We thank John Asker, two anonymous referees, Simon Anderson, Cédric Argenton, Ghazala Azmat, Matthew Ellman, Rosa Ferrer, Lisa George, Sergei Guriev, Andrés Hervas-Dráne, Christiaan Hogendorn, Doh-Shin Jeon, Niko Matouschek, Martin Peitz, Helena Perrone, Maria Petrova, Andrew Rhodes, Francesco Sobbrio, Joel Waldfogel, and Pai-Ling Yin for insightful comments and conversations as well as participants in seminars and conferences in Barcelona, Copenhagen, Florence, Hamburg, Marseille, Moscow, Munich, Rome, Santander, Tilburg and Toulouse. Germano thanks AMSE-IMéRA at Université Aix-Marseille for support and hospitality. The authors acknowledge financial support from the Fundación BBVA grant "Innovación e Información en la Economía Digital" and from the Spanish Ministry of Economy and Competitiveness under project grants ECO2014-56154-P (Alaoui) and ECO2017-89240-P (Germano), as well as the Ramon y Cajal grant and the Severo Ochoa Program for Centers of Excellence in R&D, grant SEV-2015-0563. All mistakes are our own.

†Universitat Pompeu Fabra and Barcelona Graduate School of Economics, larbi.alaoui@upf.edu

‡Universitat Pompeu Fabra and Barcelona Graduate School of Economics, fabrizio.germano@upf.edu

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 even when readers (or television viewers) and firms are rational and unbiased, readers spend more time on the news than they would like and not necessarily on the topics they prefer.[3] While this need not have a large effect on readers' utility levels, it can seriously alter the composition of stories read. The paper thus highlights a potential fragility in the choice of stories and topics that the press covers more prominently. Given readers' time constraints, news items that are relevant to them may be systematically crowded out as a result.

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 framework can also be used to study social media, public media, advertising and search.

We consider a market for news with profit-maximizing media firms facing utility-maximizing readers or television viewers. 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. In particular, they can read multiple stories and decide how much time to spend on any of the given outlets. 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

[1] According to Eric Schmidt, the former 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). A recent survey by the Pew Research Center indicates that a majority (54%) of Americans consider that "journalists are more important in today's news environment, because they help make sense of all the information that is available," (Pew Research Center, 2013).

[2] Strömberg (2015) surveys the interplay of media and politics; Pew Research Center (2007) and Williams and Delli Carpini (2011) study democracy and public knowledge in a changing media environment.

[3] We refer to the consumers throughout the paper as readers, but our approach can also be seen, for the most part, as applying to viewers as well.

on television, and our model can be applied to either. Readers can also switch from one media outlet to another or possibly return to read articles that they previously skipped. An individual's utility from reading an article depends on its "newsworthiness," which is a function of its relevance and entertainment value, 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 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, when skipping costs are not too small, despite their lack of bias, media 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 different topics from those that readers want. This result is not inconsistent with the findings of a recent survey, according to which 65% of Americans state that "news organizations focus on unimportant stories," (Pew Research Center, 2013). 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 when there is a zero cost of switching from one outlet to another and even when readers have no uncertainty over the rankings and newsworthiness of the stories. Moreover, 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.

Next, we study whether allowing firms to charge a fee to access their content can restore reader-efficiency. We show that reader-efficient rankings can be achieved under some conditions, but only when the revenues that can be obtained from readers are not too small compared to the ones that can be obtained from advertisers.[4]

Finally, we study two applications of our theory. First, we briefly discuss how a natural extension of the framework allows to study the optimal placement of advertisements as part of its strategy of

[4]It appears that in the current media landscape, revenues obtained from readers are typically just a small fraction of total revenues (Newman et al. 2017).

ranking more or less newsworthy stories. We then study 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.

Overall, this framework serves as a tractable model to analyze the intensive margin of consumer demand and firm decisions for a wide range of media platforms. This framework is particularly amenable to being extended in various directions so as to analyze different aspects of the media. It applies to the large number of media contexts in which readers have non-unit demand and a processing cost of consuming or skipping news items, and in which firms can influence the order in which readers view these items.

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), ownership (Anderson and McLaren, 2012) and 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 neutral and fully rational consumers and firms.[5] We view this as a supply-driven bias. Our paper also 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 on those outlets.

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

[5] 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.

the resulting quality of matches.[6] This literature typically assumes consumers who buy at most one unit of a given product, thereby focusing on the *extensive* margin. By contrast, in our model, the time spent on the outlets can vary, and therefore the *intensive* margin of consumer demand is key. Consumers can consume multiple news items, which are drawn from multiple news topics and which can differ in terms of a further quality dimension, namely, newsworthiness; both the quantities and qualities can matter to our consumers and firms. At the same time, our paper focuses specifically on the market for news and possible political economy implications. Within this context, it studies the effect on news consumption of sub-optimal rankings of news items from distinct topics, and emphasizes the critical externalities that this implies to the general level of informativeness of consumers.

Finally, the paper also relates to the rapidly expanding literature studying the effects of technological innovations in digital media on news and advertising markets. Athey and Gans (2010) study the effects on news readership of innovations in the technology of advertising from a two-sided market perspective; George and Hogendorn (2012), Dellarocas et al. (2013), Chiou and Tucker (2017) and Jeon and Nasr (2016) and Athey et al. (2017) study the role of aggregators and hyperlinks as innovations in current news markets. Finally, Hong (2012) studies the effect on online news readership of news media firms adopting social media platforms such as *Twitter*; De Cornière and Sarvary (2018) study attention-constrained consumers who can access newssites directly or through a social media platform such as *Facebook* to see the effect among other things on the quality of news provided.

To 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 diverse issues while keeping track of the two-sided nature of media markets in a tractable manner.

The paper is structured as follows. Section 2 introduces the framework, Section 3 shows the main results. Section 4 discusses three extensions, and Section 5 concludes. All proofs are in the Appendix.

2 Model

Media firms and stories of the day. Consider a media firm whose actions consist in fully ranking the stories of the day. Let S denote the set of **stories**, which for simplicity we assume to be divided into two categories of topics covered, A and B, so that $S = S_A \cup S_B$, where S_k contains stories on topic k, with $k \in K = \{A, B\}$. Topics could represent broad categories, such as international and domestic news, politics or entertainment, or they could be more specific categories, such as news on the Middle East. We assume that S has cardinality N and that the media firm has access to all stories. The elements of S are denoted by $s_n^k \in S_k$

There are two firms, denoted $i \in I$, where $I = \{1, 2\}$. Their strategies consist in fully ranking

[6]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.

the stories in S. To describe the strategies of the media firm, if $\mathcal{P}_N$ denotes the set of total strict rankings of the elements of S, then a **strategy** of the firm, $\sigma \in \mathcal{P}_N$, is a completely ordered N-tuple of stories of the day. Thus 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 placing a story toward the end of the ranking.

Given the set of stories S, media firm i chooses σ^i to maximize **expected profits**, which, with a unit price per story read and zero fees collected from viewers, reduces to:[7]

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

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

Readers' actions and preferences. 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.[8]

Assume that the readers all know the set S and that they need to read a story in order to consume the content. Any given story $s_n^k \in S$ is characterized by a level of **newsworthiness** $\lambda(s_n^k) \in [0,1]$. 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.

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** outlets (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 utility of stopping to 0. Note that the firm's choice of ordering has taken place *before* the reader's decision, and so the firm does not respond to each reader's choice by reordering the stories.

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

[7] In Section 4 we consider more general profit functions that include factors such as viewer fees and revenues derived from airing time-consuming advertisements.

[8] 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.

$H_0 = \emptyset$ 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 $\sigma^i = (\sigma^i_1, ..., \sigma^i_N)$, if at time t he reads story σ^i_n, then the next observed story is σ^i_{n+1}, where $\sigma^i_n = \emptyset$ for $n > N$;

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

SW when a reader switches from outlet i to a thus far *unopened* outlet j, he observes the first headline of outlet j, σ^j_1; otherwise, if j had already been previously accessed, then he returns to where the cursor was when he left off.

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 $0 \leq \nu_{SK} \leq \nu_{RD}$. 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^k_t on this topic, in all periods up to and including period t. This total amount is expressed as

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

where $x^k_0 = 0$.

Assume readers have the same instantaneous utility functions, $u_k(\cdot)$, for $k \in \{A, B\}$, which we assume satisfy $u_k(0) = 0$ and are increasing ($u'_k(\cdot) > 0$) and twice continuously differentiable. If $u''_k(\cdot) = 0$ (linear case), 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: their readers' interest in the subject grows as they read more about it. If $u''_k(\cdot) < 0$, then the agent has diminishing marginal utility of reading additional stories on a topic. We further assume that the costs satisfy $c(0) = 0$ and are increasing ($c'(\cdot) > 0$) and (weakly) convex ($c''(\cdot) \geq 0$). For expositional reasons, throughout the paper, the cases $u_A(x) = x$ and $u_B(x) = x^2$ for the instantaneous utility functions on topics A and B respectively, and $c(\tau) = \tau$ or $c(\tau) = \tau^2$ for the cost function, will play a particularly important role.

We are now in position to define the reader's maximization problem. At period $t = 0$ the agent chooses actions $(a_1, \ldots, a_T) \in \{RD, SK, SW, ST\}^T$ that maximize the **expected utility** function

$$U_0(a_1, \ldots, a_T) = \sum_{k \in K} u_k(x^k_T(a_1, \ldots, a_T)) - c(\tau_T((a_1, \ldots, a_T))), \tag{2}$$

where, we assume that when 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 zero. The reader's problem can be viewed as a standard Bellman equation, as discussed in Appendix A.[9]

Timing and Equilibrium. The timing of the game is as follows:

Stage 1 Given the set of stories S, each media firm chooses a ranking of the stories $\sigma^i(S)$. All rankings are observed by the readers.

Stage 2 There are multiple subperiods $t \in \{1, \ldots, T\}$. At $t = 1$, readers in mass M_1 have their cursor on the first headline of firm 1, and readers in mass M_2 have their cursor on the first headline of firm 2. In this and subsequent subperiods $t = 2, \ldots, T$, they choose an action a_t for every t, consume the corresponding news item and incur the corresponding cost, until they choose the terminal action ST. The cursor position is updated after every action a_t.

Stage 3 Final payoffs of the firm and the readers are realized.

This leads to an extensive-form game Γ_{ext} between the media outlets and the readers. Given the media outlets' strategies in Stage 1 and given that consumers are individually negligible and independent of each other, consumers' expected demand and hence the media outlets' expected traffic as a function of the ranking, is always well-specified and straightforward to derive for any profile of media firms' strategies in Stage 1 (see Appendix A).[10] This allows us to reduce the game Γ_{ext} to a simultaneous game of complete information Γ between the firms in I. We study Nash equilibria of the game Γ.

Discussion of the model. The essential features of our model are that consumers do not see all the news at once, that they access ranked stories through given menus of choices, and that they incur reading, skipping and switching costs when processing the news. These attributes hold not only for online newspapers but also for other media types, including television, radio, print newspapers and magazines, as well as social media and other digital platforms. Note, moreover, that the costs here are not only of time, but can also be interpreted as costs of cognition. In other words, even if only a flew clicks and scrolls could lead to another page, given the current competition for our attention, these may be still be relatively high compared to their utility, given the scarcity of cognitive resources.

The framework allows us to capture important differences between media types through different costs of processing information. 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. Table 1 provides a conjecture of these costs, although these may of course vary. For the case of skipping costs, high refers to costs that can

[9]We use the term 'expected' utility to also cover the case where agents may be uncertain about the state of the world, which we study as a natural and realistic extension of the basic model in Section 4.1.

[10]Throughout the paper, we assume that, whenever the consumer is indifferent between two plans of action (or continuation plans), he always chooses the plan that maximizes the profits of the outlet he is initially on, at any given time t. If there are more than one such plans, then he randomizes (uniformly) among them. This assumption makes the selection $\mu_n^{k,i}$ single-valued.

Table 1: Skipping, switching and reading costs by media type

	skipping cost (ν_{SK})	switching cost (ν_{SW})	reading cost (ν_{RD})
Online news	low	low	low
Newspaper	medium	medium	low
TV news	high	low	medium
Radio news	high	low	medium

approach the reading cost, low means they are not too far from zero and medium means they are between the two but likely bounded away from both.[11]

As we will see, this has implications for the amount and type of newsworthy stories eventually consumed. But even platforms such as *Twitter* and *Facebook* and blogs in general, typically maintain a high degree of control over the manner in which news or information is displayed. *Facebook*, for instance, has a newsfeed which provides users with a ranking of postings. To the extent that their incentives may also be to keep consumers reading more "news" stories, our model may be applied to show that similar tensions to the ones we will study in the following sections may arise here as well.

3 Main results

We present here our key results. We first focus on the case in which the switching costs are arbitrarily high, so that each firm effectively has a monopoly over its market share. We then consider the case of competition, or lower switching costs. Lastly, we analyze the case in which the firms can charge for consumer access. Throughout this section, we maintain that $u_A(x) = x$ and $u_B(x) = x^2$ and consider both linear cost functions of form $c(\tau) = \tau$ and strictly convex ones of form $c(\tau) = \tau^2$.[12] When discussing welfare implications, we will first discuss reader-efficiency, before discussing overall welfare, which includes producers.

3.1 Monopoly

We assume here that the switching cost (ν_{SW}) is prohibitively large, so that consumers never switch outlets. This allows us to view each outlet as a monopoly. We first study how a reader can be induced to read more than he wishes. We then move to situations where the reader can not only be induced

[11] We thank an anonymous referee for suggesting including such a table.

[12] All our results hold under more general assumptions on both utility and cost functions. A particularly natural assumption, that can be shown to be necessary for some results, is that the functions $u_B(\cdot)$ and $c(\cdot)$ be strictly convex. This assumption is not necessary for Proposition 1 on extra stories, however, as will be made clear below. The simple forms assumed throughout this section allow us to state and prove the results in a straightforward and transparent way.

to read more, but where the more newsworthy stories are crowded out, in the sense that they are not read.

Before starting our analysis of equilibrium rankings, we note that when the skipping cost (ν_{SK}) is sufficiently low, the reader-efficient rankings are equilibria (and payoff-equivalent for the firms to all other equilibria), since any (undesired) extra story inserted by the firm will simply be skipped by the readers.

Extra stories read. Suppose there are two stories, s_h and s_l on (linear utility) topic A, with $\lambda_h = \lambda(s_h) > \nu_{RD}$ and $\lambda_l = \lambda(s_l) < \nu_{RD}$. The reader then wishes to read only story with newsworthiness λ_h, and not the one with λ_l. For now, suppose that the skipping cost is equal to the reading cost, $\nu_{SK} = \nu_{RD}$, so that the reader never skips a story that has positive newsworthiness. Then, if the utility from reading both stories is non-negative,

$$\lambda_h + \lambda_l - 2\nu_{RD} \geq 0, \tag{3}$$

then the firm can induce the reader to consume both stories, meaning that the reader reads more than he would have preferred to. Rewriting (3) as, $\lambda_h - \nu_{RD} \geq \nu_{RD} - \lambda_l$, allows the condition to have a visual interpretation. This can be seen in Figure 1a, where the shaded area C represents the net utility loss of reading the low newsworthiness story s_l, and the area D represents the net utility gain of reading the high newsworthiness story s_h. Intuitively, the reader is willing to incur a net disutility of reading an uninteresting story, if he will then read one that is interesting enough. The same would hold for a lower ν_{SK}, if the following condition holds as well:

$$\nu_{SK} \geq \nu_{RD} - \lambda_l. \tag{4}$$

This ensures that the cost of skipping the low newsworthiness story s_l is higher than the net disutility of reading it (Figure 1b). Notice that in both cases, the more interesting story, which the consumer wishes to read, is placed after the less interesting one. Notice also that put together, (3) and (4) imply that, for this strategy to work, the following must hold:

$$\lambda_l \geq \max\{2\nu_{RD} - \lambda_h, \nu_{RD} - \nu_{SK}\}. \tag{5}$$

Suppose now that there are more stories of newsworthiness λ_l. Again, ignoring first the skipping costs (i.e., assuming $\nu_{SK} = \nu_{RD}$), the maximum stories m_l of low newsworthiness λ_l that can be inserted before story s_h is:

$$m_l = \lfloor \frac{\lambda_h - \nu_{RD}}{\nu_{RD} - \lambda_l} \rfloor, \tag{6}$$

as shown in Figure 2a. Accounting once more for the skipping cost leads to the same condition as before (Condition (3)), for identical reasons. That is, this condition ensures that the cost of skipping the story is higher than the disutility of reading it.

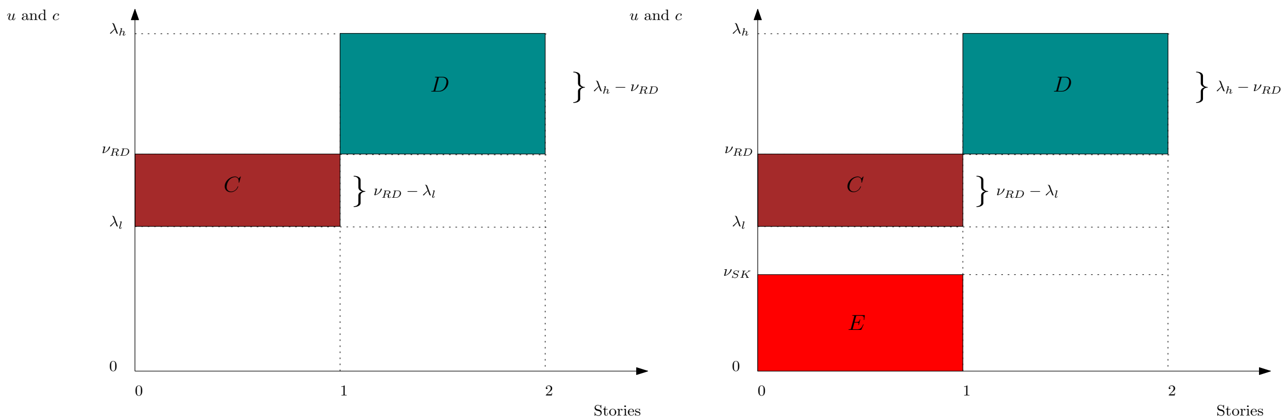

Figure 1: **One extra story read.** Left panel (a): Story with newsworthiness λ_l inserted before story with newsworthiness λ_h (Area $D >$ Area C). Right panel (b): Skipping costs still too high to skip λ_l (Area $E >$ Area C). The x-axis represents story order, the y-axis represents newsworthiness.

Introducing more stories of newsworthiness λ_h does not complicate the analysis. In particular, assume there are m_h stories of newsworthiness λ_h. As can be seen from Figure 2b, Condition (6) on the maximum number of inserted stories m_l of newsworthiness λ_l would then simply change to:

$$m_l = \lfloor \frac{m_h(\lambda_h - \nu_{RD})}{\nu_{RD} - \lambda_l} \rfloor. \tag{7}$$

The reasoning above leads us to the following proposition.

Proposition 1 (**Extra stories read (linear preferences)**). *Let Γ be a game where readers have utility functions $u_A(x) = x$ and cost function $c(\tau) = \tau$, and suppose that there are m_h stories on topic A of newsworthiness $\lambda_h > \nu_{RD}$, implying that the reader-efficient equilibrium ranking entails that the consumer reads all m_h stories. Then a necessary and sufficient condition on a story s_l on topic A of newsworthiness $\lambda_l < \nu_{RD}$ to be inserted, such that it is also read in equilibrium, is:*

$$\lambda_l \geq \max\{(m_h + 1)\nu_{RD} - m_h\lambda_h, \nu_{RD} - \nu_{SK}\}, \tag{8}$$

where the reading and skipping costs satisfy $0 < \nu_{SK} < \nu_{RD} < \lambda_h$. The maximum number m_l of extra stories of newsworthiness λ_l that can be inserted such that they are all read, together with the m_h stories of newsworthiness λ_h, is:

$$m_l = \lfloor \frac{m_h(\lambda_h - \nu_{RD})}{\nu_{RD} - \lambda_l} \rfloor. \tag{9}$$

Notice that, given the stories read, the strategy of placing stories of newsworthiness λ_h later

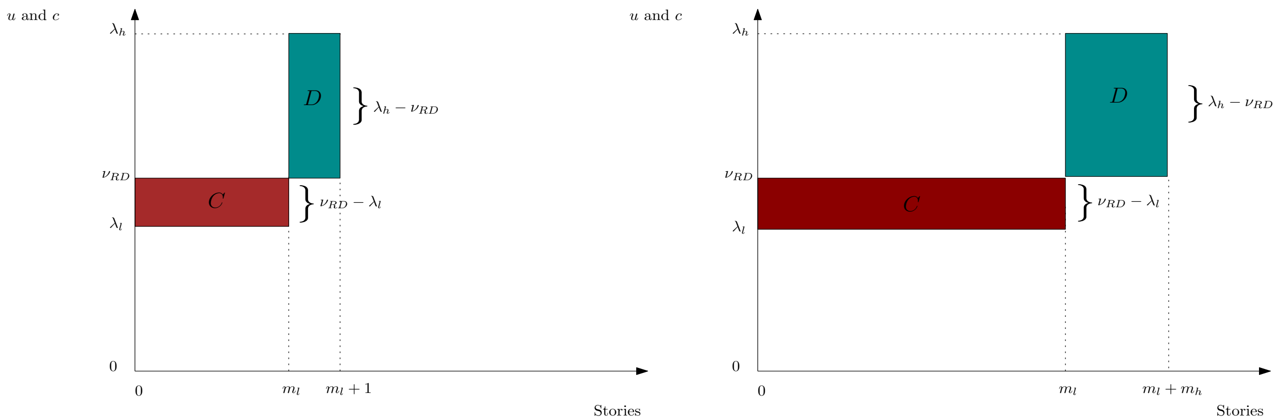

Figure 2: m_l **extra stories read.** Left panel (a): m_l stories with newsworthiness λ_l inserted before one story with newsworthiness λ_h (Area $C = m_l(\nu_{RD} - \lambda_l)$ = Area $D = \lambda_h - \nu_{RD}$). Right panel (b): m_l stories with newsworthiness λ_l inserted before m_h stories with newsworthiness λ_h (Area $C = m_l(\nu_{RD} - \lambda_l) = m_h(\lambda_h - \nu_{RD})$ = Area D).

and stories of λ_l earlier cannot be improved upon. It is only if the media outlet cannot induce the consumer to read a story of newsworthiness λ_l that a story of newsworthiness λ_h is placed first. More generally, for constant marginal cost, the main feature is to have stories with value $\lambda(s) > \nu_{RD}$ after those of value $\lambda(s) < \nu_{RD}$, when the consumer can be induced to read stories of the latter type. Still in the special case of constant marginal cost, we also note that firms can use other strategies, such as alternating from first having a story of newsworthiness λ_l to one of newsworthiness λ_h, and so forth. In particular, this strategy can be used on $\min\{m_l, m_h\}$ stories of newsworthiness λ_l followed by λ_h. Such a strategy may be used by firms, for example, when there are readers that may lose patience from reading too many uninteresting stories.

Strongly time-constrained readers and heterogeneity. We refer to readers with a higher cost of time as being more time-constrained. To illustrate what happens when time costs increase, suppose we change the cost function in Proposition 1 from $c(\tau) = \tau$ to $\tilde{c}(\tau) = \kappa \cdot c(\tau)$ for $\kappa > 1$. Because increasing the cost of time decreases both the net utility gains from reading newsworthy sties but also increases the cost of reading the extra stories inserted, it is not difficult to see that, increasing the cost of time from $c(\cdot)$ to $\tilde{c}(\cdot)$ reduces the scope for extra stories read (and similarly for stories crowded out in the next propositions), in the sense that in general, the conditions on preference parameters become more stringent, while the amount of extra stories that can be inserted decreases.[13]

[13] In Appendix B, we show that in Proposition 1 with $\tilde{c}(\cdot)$ instead of $c(\cdot)$, we get $\tilde{\lambda}_l > \lambda_l$ and $\tilde{m}_l < m_l$ for the corresponding parameters $\tilde{\lambda}_l$ and $\tilde{m}_l$ satisfying Conditions (8) and (9), respectively, when $\kappa > 1$, compared to the case $\kappa = 1$. Analogous results can be shown for Propositions 2 and 3.

The practice of placing important stories first may be explained by other factors, such as when there is uncertainty over the importance of the stories coming up, or when there is heterogeneity in reader preferences. There could be heterogeneity if, for instance, some readers are more time-constrained than others. In particular, if there is heterogeneity in the time cost, then the firms may provide important stories interspersed with the less important stories, so as not to dissuade the highly time-constrained readers from reading.

Although this is outside the scope of our model, we note that when there is such heterogeneity, the extent to which firms prefer readers to have smaller or larger skipping costs is ambiguous. This is because larger skipping costs help the firms with the strategies above of introducing extra stories, but smaller skipping costs are also useful for the more time-constrained readers to stay on and read the stories they would prefer to read. In other words, in a more complex model in which firms had some technology for increasing the readers' skipping costs, the firms' use of this technology would depend on the extent of reader heterogeneity. Moreover, as competition is increased, we also expect firms to be more limited in their ability to introduce technology that raises skipping costs.

Crowding out of stories. We now analyze the conditions under which a stronger form of extra stories read occurs, namely, one where the extra stories actually *crowd out* other stories the reader would otherwise have preferred to read. Note first that with constant marginal cost, crowding out of linear topic A could not occur. This is because the marginal benefit-marginal cost tradeoff for any story that the reader wishes to read is not affected by what is read previously. Specifically, the firm will always wish a reader to read story of $\lambda_h > \nu_{RD}$ eventually, although, as discussed above, it may have him read other stories as well. If, however, the marginal cost is not constant, and if utility of topic B is more convex than for topic A, then stories of topic A may be crowded out. This is characterized in the next proposition.

Suppose that stories on topic A have newsworthiness $\lambda^A \in (\nu_{RD}^2, 3\nu_{RD}^2)$, and that stories on topic B have newsworthiness $\lambda^B = \nu_{RD}$. This implies that the consumer wishes to read exactly one story on topic A, and is unwilling to read more than that. The assumption on topic B is made for simplicity and can be relaxed, but it is used to effectively consider the extreme case in which the net utility gain from reading stories on this topic can be at most zero. As shown in Figure 3, in which $\lambda^A = 2\nu_{RD}^2$, the agent has positive net utility from reading that story, and nothing else. But if stories of topic B are placed beforehand and the skipping cost is sufficiently high, then the reader will read those, but not the story of topic A. This is because the utility of that story is the same as before, but the marginal cost is now high enough that the total utility gain would be negative. Hence, the reader ends up consuming only the stories of topic B, and his total utility of reading is 0. This result is formalized in the following proposition.

Proposition 2 (**Crowding out of stories**). *Let Γ be a game where readers have utility functions $u_A(x) = x$, $u_B(x) = x^2$, and cost function $c(\tau) = \tau^2$. Suppose that the stories on topic A have newsworthiness $\lambda^A \in (\nu_{RD}^2, 3\nu_{RD}^2)$, and that there are $m_B > 1$ stories on topic B, all of newsworthiness λ^B*

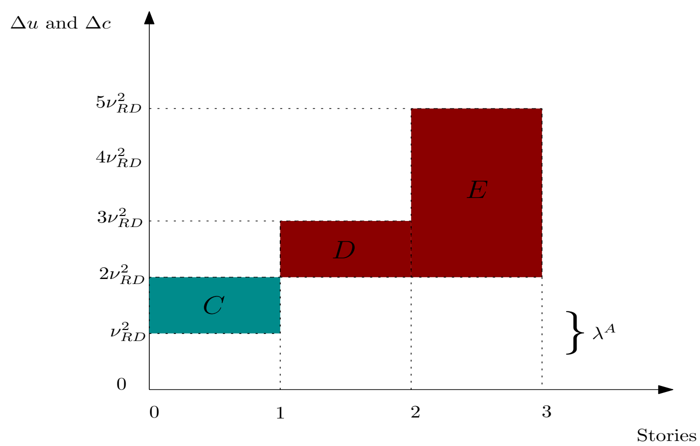

Figure 3: **Crowding out.** Reading just story of topic A gives utility $u_A(\lambda^A) = \lambda^A = 2\nu_{RD}^2$ and cost $c(\nu_{RD}) = \nu_{RD}^2$, leaving net utility ν_{RD}^2 (Area C). The same story placed after two stories of topic B, still gives incremental utility of $\lambda^A = 2\nu_{RD}^2$, but the incremental cost is now $c(3\nu_{RD}) - c(2\nu_{RD}) = 5\nu_{RD}^2$, leaving a net disutility of $3\nu_{RD}^2$ (Area E). The reader does not read the story of topic A after two of topic B. Similarly, if the story of topic A is placed after one story of topic B it is not read, since it gives a net disutility of ν_{RD}^2 (Area D).

such that $\lambda^B = \nu_{RD}$, implying that the reader-efficient equilibrium ranking entails that the consumer read only one story of topic A. Then a necessary and sufficient condition for story λ^A to be crowded out by the m_B stories of topic B is for the skipping cost to satisfy:

$$\nu_{SK} \geq \frac{\sqrt{\lambda^A} - \nu_{RD}}{m_B}. \tag{10}$$

When topic A with the more newsworthy stories has $u_A(\cdot)$ linear, whereas, $u_B(\cdot)$ and $c(\cdot)$ are sufficiently convex and have more stories available, then not only can an outlet have the reader read more stories than he would like, but it can do so in a way that the reader no longer reads the more newsworthy stories of topic A.

3.2 Competition

The propositions above focus on the case in which the switching cost is high enough that the readers never switch outlets and outlets act as monopolists. Here we consider the case in which switching costs are lower, including the limiting case of zero cost, or perfect competition.

The previous graph can be used to illustrate how the crowding out of stories result can hold even in the limit of perfect competition. To see this, suppose that there are two firms ($I = 2$), each with half the market share ($M_1 = M_2 = 1/2$). The newsworthiness of the stories of topics A and B are as before, and so the readers only wish to read the story on topic A of newsworthiness λ^A.

To obtain crowding out to occur with two firms in competition, a stronger condition needs to be satisfied. Consider first the extreme case of perfect competition where $\nu_{SW} = 0$. In this case, there is always a reader-efficient equilibrium, because if a firm deviates to a non-reader efficient strategy, then the other firm will capture the entire market. However, there can also exist equilibria that are not reader-efficient. In particular, crowding out can occur. For instance, in Figure 3, in which $m_B = 3$ stories of topic B are read when switching costs are prohibitively high, the same equilibrium remains when switching costs are zero. This is because even though a firm can deviate by placing at the top of the ranking the story of topic A that the reader wishes to read, and have the entire market reading one story, this generates less profit than having 1/2 the market, but where each reader reads 3 stories. (It can also be shown that placing the story a little earlier, but not at the top, would not lead readers to switch outlets.) More generally, if the firms do not have the same share of the market, then letting $M = \min\{M_1, M_2\} = \min\{M_1, 1 - M_1\}$, the crowding-out equilibrium occurs if $m_B \geq 1/M$.[14]

In the intermediate case in which switching costs are non-zero, but not necessarily prohibitively high, then, for crowding out to be an equilibrium, it suffices either for the condition above to hold, or for the switching cost to be high enough that it is not compensated by the utility gain. If the latter case holds, then the reader-efficient equilibrium will no longer exist. We summarize these results in the next proposition.

Proposition 3 (Crowding out of stories (competition)). *Suppose there are two firms with market shares* $0 < M_1, 1 - M_1 < 1$*, and that all the conditions of Proposition 2 hold. A crowding-out equilibrium occurs if and only if at least one of the two following conditions is satisfied:*

$$m_B \geq 1/M, \textit{for } M = \min\{M_1, 1 - M_1\}, \tag{11}$$

or

$$\nu_{SW} \geq \sqrt{\lambda^A} - \nu_{RD}. \tag{12}$$

Moreover, jointly with the conditions of Proposition 2, Condition (12) is necessary and sufficient for only the crowding-out equilibria to exist.

3.3 Charging for Consumer Access

We now consider the case in which media firms can charge a price that gives consumers access to their content. In particular, we show that charging for access can lead to a return to reader efficiency, under some conditions.[15] The crowding-out equilibria can still exist (under some conditions), however, both with monopoly and with competition, as we discuss below.

Suppose that each firm $i \in \{1, 2\}$ can charge a fixed access fee, $p^i \geq 0$, in stage 1 of the game, that

[14] A similar result holds with $I > 2$ firms. Specifically, set $M = \min\{M_1, \ldots, M_{I-1}, 1 - \sum_{i=1}^{I-1} M_i\}$, and the rest of the analysis goes through.

[15] Hagiu and Jullien (2011, 2014), in different frameworks, also obtain that charging fees may bring rankings closer to efficiency.

allows readers to access i's website. Formally, within the basic game Γ (or Γ_{ext}), the fees $p = (p^1, p^2)$ are added as strategic variables to the firm's rankings σ so that:

$$\Pi_i(\sigma, p) = \alpha \sum_{k \in K} \sum_{s_n^k \in S_k} \mu_n^{k,i}(\sigma, p) + p^i \mu_{fee}^i(\sigma, p)\,, \tag{13}$$

where $\alpha > 0$ represents the price generated per story click (we had previously normalized it was 1, as it had no impact on the previous results), and μ_{fee}^i is the share of agents who choose to pay the access fee price p^i to firm i.

This adds a fixed (state-independent) viewer fee component – the sum of all fees received – to the firm's profit function in Section 2. The reader's expected utility function is as before, except that the fee p^i is now subtracted when the reader accesses firm i's website for the first time.

Consider first the case of (sufficiently) high switching costs at which each firm is effectively a monopolist, as in Section 3.1. 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 p^i. In particular, note that for α sufficiently high, the firm will not change its rankings of stories, but instead set p^i at exactly the amount of the consumer surplus (utility of consuming stories net of cost). Instead, if α is sufficiently close to zero, then the firm will choose the reader efficient ranking, again setting p^i to the surplus level. In both cases, the firms appropriate all the consumer rent. The difference lies in which ranking is provided to the viewers.[16]

Formally, returning first to the linear setting of Proposition 1, the following result holds.

Proposition 4 (**Pricing with linear preferences (monopoly)**). *Suppose preferences and costs are as in Proposition 1, and that $\lambda_l < \nu_{RD}$ satisfies Condition (8), meaning that at least one story of newsworthiness s_l is read. Moreover, suppose that there are m_l such stories read, where m_l is determined by Condition (9). Then, if $\alpha > \nu_{RD} - \lambda_l$, the same reader-inefficient equilibria remain as the only equilibria, with the addition that the monopoly firm sets the access price at:*

$$p^i = m_h(\lambda_h - \nu_{RD}) + m_l(\lambda_l - \nu_{RD}). \tag{14}$$

Otherwise (if $\alpha \leq \nu_{RD} - \lambda_l$), the firm provides the reader-efficient ranking, and sets the price at:

$$p^i = m_h(\lambda_h - \nu_{RD}). \tag{15}$$

In both cases, the readers' net utility is 0.

Moving to the case of crowding out and the setting of Proposition 2, the following result holds.

[16] In the results that follow, the reader-efficient ranking refers to what the reader would wish to read, absent of access fees.

Proposition 5 (**Pricing with crowding out of stories (monopoly)**). *Suppose preferences and costs are as in Proposition 2. Then, if* $\alpha > \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$*, the reader-inefficient ranking, with access price set at* $p^i = 0$*, is the only equilibrium if and only if Condition (10) holds. Otherwise (if* $\alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$*), the reader-efficient ranking is provided, and the firm sets the access price at:*

$$p^i = \lambda^A - \nu_{RD}^2. \tag{16}$$

In both cases, the readers' net utility is 0.

The reason that the access price is $p^i = 0$ in the case of reader-inefficiency is that the reader's net utility was already 0 in that case, and so the monopoly could not extract more surplus from the reader. This is a feature of the simplifying assumption that $\lambda^B = \nu_{RD}$; had it not been for this assumption, the price would have been strictly positive.

We now consider the case of competition, in an analogous way to Section 3.2, and specifically to the setting of Proposition 3. Then, a crowding out equilibrium may still exist, for high enough α. In that case the price will be $p^i = 0$ as before, again by virtue of the utility already being zero.[17] We do not include all the possible conditions as these are lengthy, but we include important conditions for which crowding out equilibria remain, including for low switching costs.

Proposition 6 (**Pricing with crowding out of stories (competition)**). *Suppose there are two firms with market shares* $0 < M_1, 1 - M_1 < 1$*, and that all the conditions of Proposition 2 hold. If* $\alpha > \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$*, then the reader-inefficient ranking with access price set at* $p^i = 0$ *is an equilibrium if and only if Condition (12) of Proposition 3 or the condition* $\alpha > \frac{\lambda^A - (\nu_{RD} + \nu_{SW})^2}{m_B M - 1}$ *is satisfied (where again* $M = \min\{M_1, 1 - M_1\}$*). Moreover, jointly with the conditions of Proposition 2,* $\alpha > \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$ *and Condition (12) are necessary and sufficient for only the reader-inefficient equilibria to occur. In all the above cases, the readers' net utility is 0. Otherwise (if* $\alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$*), the reader-efficient ranking is provided, and the access price is set according to a mixed strategy distribution with support inside* $[0, \lambda^A - \nu_{RD}^2]$ *Readers' net utility need not be 0 in this case.*

In practice, there are several caveats that make charging access possibly difficult. First, heterogeneity in readers make it difficult for a firm to target perfectly each agent by their exact willingness to pay. Second, firms may generate substantial revenues from advertising, which itself links to number of clicks (stories read). If so, and if the revenue that firms can get from charging readers is not enough to compensate the lost advertising revenue (for instance, if the willingness to pay of readers is low), then pricing would not necessarily lead to reader efficiency. Lastly, consumers may be unwilling to pay a transaction cost required to pay the fee, especially for online content.

[17] Without the assumption that $\lambda^B = \nu_{RD}$, the reader inefficient ranking would remain for high enough α, but the price would be 0 when the switching costs are $\nu_{SW} = 0$.

3.4 Aggregate Welfare

We have so far focused on the reader-efficiency of firm rankings of stories and have not discussed total surplus, which also includes firm profits. The reason for this is that the importance of the media, and of having reader-efficient rankings, is not solely about utility, but also about information acquired by the readers. This is especially relevant in a political economics context. While we have not modeled information explicitly, nor potential externalities of information, we believe nonetheless that reader-efficient rankings can provide some guidance on the issue. We discuss a political economics context in which such an informational externality is present in Section 4.3, and discuss here, briefly, the case of total surplus, that is, the sum of profit and reader utility, when such externalities are ignored. Consider thus total surplus defined in the following way:

$$TS(\sigma) = \beta \sum_{i \in I} \Pi_i(\sigma) + (1 - \beta) CS(\sigma), \tag{17}$$

where $\beta > 0$ is a welfare weight on profits, since the utility functions may not be normalized to the same units as firm profits, and CS is simply the total utility of all readers.

Again, β is crucial in determining whether the reader-efficient ranking is also the overall efficient ranking. When β is sufficiently small ($\beta \to 0$), the reader-efficient ranking is also surplus maximizing. However, when β is large ($\beta \to 1$), then the ranking that maximizes firm's profit, which need not be the reader-efficient one, also maximizes total surplus. Our analysis, which focuses on reader efficiency, can be interpreted as being concerned with the case where β is small, meaning that the weight on firms' profits is significantly less important than the weight on consumers' utilities.

4 Applications and Further Results

We consider three basic extensions of our theory, allowing for uncertainty, advertising and political bias, before discussing some political economy implications.

4.1 Uncertainty

Throughout the paper, we assumed one state of the world, for the sake of exposition. In practice, consumers may be uncertain about the state of the world in the sense that they do not know which stories (with respective newsworthiness) are available ex ante, but rather learn this as they consume the news. We here extend the model to allow for uncertainty in the state of the world.

Suppose that, 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 $\mathcal{S}$, 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 knowledge assumption is that a newspaper's editorial stance and presentation style are generally known to the public. 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 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 we discuss in the Appendix, uncertainty 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, thereby exacerbating the reader inefficiencies of Section 3.1. Intuitively, 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 also consistent with results from the empirical search literature (e.g., Jeziorski and Segal, 2015).

4.2 Advertising with Time-Constrained Consumers

Advertising can affect media consumption through the time costs that it imposes as well as through the screen space and attention 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 used to study optimal placement of advertising and its implications for the news ranking and consumption. Importantly, advertising can lead not only to extra time cost incurred by the readers but also to further crowding out of newsworthy stories.[18] Since time costs vary with media type, our analysis also suggests that optimal reporting and advertising strategies might vary across media types.

4.3 Political Outcomes and Time-Constrained Voters

The results of Section 3.1 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 can 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 (or watch more television) than they wish to, while being systematically *less* informed on relevant subjects. In a political economy setting with voting, this can 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 politically biased firms.

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).[19] 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. We extend it as follows:[20]

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

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 weighted by newsworthiness and content. Recall that $\mu_n^{k,i}(\sigma)$ is the share of the readership that firm i receives on topic k, and λ_n^k is newsworthiness. When $\alpha_k^i = 0$ we recover the profit function of Section 2. Setting $\alpha_k^i \neq 0$ indicates that firm i cares about which newsworthy stories consumers read. Newsworthiness λ_n^k becomes a proxy for the quantity of information received by the readers, while the content variable z_n^k refers

[18] The source of disutility 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 yield a further justification that limiting the quantity of advertising can be beneficial by limiting the amount of crowding out of news stories due to advertising.

[19] 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) and Prat and Strömberg (2013) contain recent surveys.

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

to the intrinsic information, whether positive or negative, transmitted. Hence, $\alpha_k^i > 0$ for topic k captures bias by firm i 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) bias in the preferences of the firm. Note that, as in the rest of the paper, the firms' strategies consist only of a ranking the stories; we have not extended the model to allow for *slanting* the content of stories.[21] It is straightforward, then, to show that such preferences will influence the ranking of the stories as firms seek to systematically emphasize or de-emphasize 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, in their empirical analysis of media slant, Gentzkow and Shapiro (2010) 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 (Mullainathan and Shleifer (2005), Gentzkow and Shapiro (2006), Chan and Suen (2008) and Sobbrio (2014)).

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, then, whether or not there is also supply-driven heterogeneity in biases, the market outcome may be one of differentiation.[22] 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.

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. As a further application of our benchmark model, suppose we add a *public media firm* that we assume maximizes the utility of the average reader (or viewer). With homogeneous readers, it is immediate that such a firm

[21] 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.

[22] 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.

automatically chooses the reader-efficient ranking. Hence, if such a firm is present in the market and if switching costs are low enough, then *all* equilbria are reader-efficient. Importantly, the presence of such an easily accessible public outlet does not imply that it captures the entire market from the other profit-maximizing firms. Rather, its presence changes the equilibrium itself: all firms choose to provide the reader-efficient ranking. The public outlet effectively sets a standard that other outlets adhere to.[23]

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 this market, we have developed a framework in which media firms the rank stories or news items, while consumers can browse through the menus of choices offered by the firms. This provides a unifying framework that accommodates diverse types of traditional and new media, including television or social media platforms such as *Facebook* and *Twitter*, and that captures differences between media types through the time costs of accessing and processing the information 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 spend more time consuming news than they would prefer to. Moreover, because news items are typically drawn from multiple topics, they may also consume 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 news consumers reading or viewing more media content, as well as conditions under which important stories are crowded out. We find that, besides the costs of processing the news, the crucial factors are the shapes of individuals' time cost and utility functions.

The framework lends itself naturally 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 analyses 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.

[23]Such a standard-setting role for public media is emphasized in Cushion (2012). A recent and growing literature on comparative studies of media systems in advanced democracies finds that a strong presence and funding of public media is associated with a higher level of knowledge of the general public, especially on public affairs issues; see Aalberg and Curran (2012) and Strömbäck (2017).

References

[1] Aalberg, T., and J. Curran (2011) (eds.) *How Media Inform Democracy: A Comparative Approach*, Routledge, London.

[2] Anderson, S.P., and S. Coate (2005) "Market Provision of Broadcasting: A Welfare Analysis," *Review of Economic Studies*, 72, 947-972.

[3] Anderson, S.P., and A. De Palma (2012) "Competition for Attention in the Information (Overload) Age," *Rand Journal of Economics*, 43(1), 1-25.

[4] Anderson, S.P., and J. McLaren (2012) "Media Mergers and Media Bias with Rational Consumers," *Journal of the European Economic Association*, 10(4), 831-859.

[5] Armstrong, M., Vickers, J., and J. Zhou (2009) "Prominence in Consumer Search," *RAND Journal of Economics*, 40, 209-233.

[6] Athey, S., and J.S. Gans (2010) "The Impact of Targeting Technology on Advertising Markets and Media Competition," *American Economic Review: Papers and Proceedings*, 100, 608-613.

[7] Athey, S., Möbius, M. and J. Pal (2017) "The Impact of Aggregators on Internet News Consumption," Mimeo.

[8] Besley, T., and A. Prat (2006) "Handcuffs for the Grabbing Hand? The Role of the Media in Political Accountability," *American Economic Review*, 96(3), 720-736.

[9] Blasco, A., and F. Sobbrio (2012) "Competition and Commercial Media Bias," *Telecommunications Policy*, 36(5), 434-447.

[10] Burguet, R., Caminal, R., and M. Ellman (2015) "In Google We Trust?," *International Journal of Industrial Organization*, 39, 44-55 .

[11] Chan, J., and W. Suen (2008) "A Spatial Theory of News Consumption and Electoral Competition," *Review of Economic Studies*, 75(3), 699-728.

[12] Chiou, L., and C. Tucker (2017) "Content Aggregation by Platforms: The Case of the News Media," *Journal of Economic and Management Strategy*, 26(4), 782-805.

[13] Cushion, S. (2012) *The Democratic Value of News*, Palgrave Macmillan, London.

[14] De Cornière, A. (2013) "Search Advertising," *American Economic Journal: Microeconomics*, *forthcoming.*

[15] De Cornière, A., and G. Taylor (2014) "Integration and Search Engine Bias," *RAND Journal of Economics*, 45(3), 576-597.

[16] De Cornière, A., and M. Sarvary (2018) "Social Media and the News Industry," Mimeo.

[17] Dellarocas, C., Katona, Z., and Rand, W.M. (2013) "Media, Aggregators and Link Economy: Strategic Hyperlink Formation in Content Networks," *Management Science*, 59(10), 2360-2379.

[18] Dyson, M. C. (2004) "How physical text layout affects reading from screen," *Behaviour and Information Technology*, 23(6), 377-393.

[19] Ellison, G., and S.F. Ellison (2009) "Search, Obfuscation, and Price Elasticities on the Internet," *Econometrica*, 77, 427-452.

[20] Ellman, M., and F. Germano (2009) "What do the Papers Sell? A Model of Advertising and Media Bias," *Economic Journal*, 119, 680-704.

[21] Gentzkow, M., and J.M. Shapiro (2006) "Media Bias and Reputation," *Journal of Political Economy*, 114(2), 280-316.

[22] Gentzkow, M., and J.M. Shapiro (2008) "Competition and Truth in the Market for News," *Journal of Economic Perspectives*, 22, 133-154.

[23] Gentzkow, M., and J.M. Shapiro (2010) "What Drives Media Slant? Evidence from US Daily Newspapers" *Econometrica*, 78 (1), 35-71.

[24] George, L.M., and C. Hogendorn (2012) "Aggregators, Search and the Economics of New Media Institutions," *Information Economics and Policy*, 24, 40-51.

[25] George, L.M., and J. Waldfogel (2003) "Who Affects Whom in Daily Newspaper Markets?," *Journal of Political Economy*, 111(4), 765-785.

[26] Germano, F., and M. Meier (2013) "Concentration and Self-Censorship in Commercial Media," *Journal of Public Economics*, 97, 117-130.

[27] Hagiu, A., and B. Jullien (2011) "Why Do Intermediaries Divert Search?," *RAND Journal of Economics*, 42, 337-362.

[28] Hagiu, A., and B. Jullien (2014) "Search Diversion and Platform Competition," *International Journal of Industrial Organization*, 33, 48-60.

[29] Hamilton, J.T. (2004) *All the News That's Fit to Sell: How the Market Transforms Information into News*, Princeton University Press, Princeton, NJ.

[30] Hong, S. (2012) "Online News on Twitter: Newspapers' Social Media Adoption and their Online Readership," *Information Economics and Policy*, 24(1), 69-74.

[31] Jeon, D.S., and N. Nasr (2016) "News Aggregators and Competition among Newspapers on the Internet," *American Economic Journal: Microeconomics*, 8(4), 91-114.

[32] Jeziorski, P., and I. Segal (2015) "What Makes them Click: Empirical Analysis of Consumer Demand for Search Advertising," *American Economic Journal: Microeconomics*, 7, 24-53.

[33] Kerkhof, A., and J. Muenster (2015) "Quantity Restrictions on Advertising, Commercial Media Bias, and Welfare," *Journal of Public Economics*, 131, 124-131.

[34] Mullainathan, S., and A. Shleifer (2005) "The Market for News," *American Economic Review*, 95, 1031-1053.

[35] Newman, N., Fletcher, R., Kalogeropoulos, A., Levy, D.A., and R.K. Nielsen (2017) *Reuters Institute Digital News Report 2017*. Reuters Institute for the Study of Journalism, Oxford, UK.

[36] Pariser, E. (2011) *The Filter Bubble*, Viking, Penguin Books, London.

[37] Petrova, M. (2012) "Mass Media and Special Interest Groups." *Journal of Economic Behavior and Organization*, 84, 17-38.

[38] Pew Research Center (2007) *Public Knowledge of Current Affairs Little Changed by News and Information Revolutions*, Pew Research Center for the People and the Press, Washington, DC.

[39] Pew Research Center (2013) *Amid Criticism, Support for Media's 'Watchdog' Role Stands Out*, Pew Research Center for the People and the Press, Washington, DC.

[40] Prat, A., and D. Strömberg (2013) "The Political Economy of Mass Media," in *Advances in Economics and Econometrics: Theory and Applications, Tenth World Congress*, edited by D. Acemoglu, M. Arellano, and E. Dekel, Cambridge University Press, Cambridge.

[41] Rhodes, A. (2011) "Can Prominence Matter Even in an Almost Frictionless Market?," *Economic Journal*, 121, F297-F308.

[42] Schroeder, E., and D.F. Stone (2015) "Fox News and Political Knowledge," *Journal of Public Economics*, 126, 52-63.

[43] Sims, C.A. (2003) "Implications of Rational Inattention," *Journal of Monetary Economics*, 50, 665-690.

[44] Sobbrio, F. (2014) "Citizen-Editors' Endogenous Information Acquisition and News Accuracy," *Journal of Public Economics*, 113, 43-53.

[45] Strömbäck, J. (2017) "Does Public Service TV and the Intensity of the Political Information Environment Matter?," *Journalism Studies*, 18(11), 1415-1432.

[46] Strömberg, D. (2004) "Mass Media Competition, Political Competition, and Public Policy," *Review of Economic Studies*, 71, 265-284.

[47] Strömberg, D. (2015) "Media and Politics," *Annual Review of Economics*, 7, 173-205.

[48] Van Zandt, T. (2004) "Information Overload in a Network of Targeted Communication," *Rand Journal of Economics*, 35(3), 542-560.

[49] White, A. (2012) "Search Engines: Left Side Quality versus Right Side Profits," *International Journal of Industrial Organization*, forthcoming.

[50] Wilbur, K.C. (2008) "A Two-Sided, Empirical Model of Television Advertising and Viewing Markets," *Marketing Science*, 27, 356-378.

[51] Williams, B.A., and M.X. Delli Carpini (2011) *After Broadcast News: Media Regimes, Democracy and the New Information Environment*, Cambridge University Press, Cambridge.

Appendix

A Readers' preferences

Readers' maximization problem as a Bellman equation. The main text considers the reader's maximization problem from period 0 for the entire subsequent periods, and chooses his action at each period accordingly. The reader is dynamically consistent, and so this suffices for our analysis. The reader's problem can alternatively be written as a Bellman equation, as we now show. Define, for each period t, and for any $v_k(x_t^k|H_{t-1}) = \triangle u_k(x_t^k, x_{t-1}^k|H_{t-1}) = u_k(x_t^k) - u_k(x_{t-1}^k)$ and $\gamma(\tau_t|H_{t-1}) = \triangle c(\tau_t, \tau_{t-1}|H_{t-1}) = c(\tau_t) - c(\tau_{t-1})$.

Then, the agent's Bellman equation, at any period t, given observed headline s_t^k, can be written as:

$$\begin{aligned} U_t(s_t^k) = \max_{\{RD,SK,SW,ST\}} \{ & v_k(x_{t-1}^k + \lambda(s_t^k)|H_{t-1}) - \gamma(\tau_{t-1} + \nu_{RD}|H_{t-1}) + U_{t+1}(s_{t+1}^k), \\ & v_k(x_{t-1}^k|H_{t-1}) - \gamma(\tau_{t-1} + \nu_{SK}) + U_{t+1}(s_{t+1}^k), \\ & v_k(x_{t-1}|H_{t-1}) - \gamma(\tau_t + \nu_{SW}|H_{t-1}) + U_{t+1}(s'), \\ & 0\} \end{aligned}$$

where s' is the first unaccessed story of the outlet that the reader would switch to.[24] Note that the last term in the maximization function, which corresponds to the action ST, is 0 because $v_k(x_{t-1}^k|H_{t-1}) - \gamma(\tau_{t-1}|H_{t-1}) = 0$.

Reader demand and existence of a Nash Equilibrium. The following lemma allows us 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 1 (**Reader demand**). *Let $\sigma = \left(\sigma^i\right)_{i\in I}$ 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, $\sigma = \left(\sigma^i\right)_{i\in I}$, 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

[24] We are grateful to an anonymous referee for suggesting this formulation of the Bellman equation.

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 Proofs

Proof of Proposition 1. We derive Conditions (8) and (9) for the slightly more general case of $\tilde{c}(\tau) = \kappa \cdot \tau$, for $\kappa \geq 1$, so as to also cover the statements on more time-constrained consumers stated in footnote 13. To see necessity of Condition (8). For m_h stories of newsworthiness λ_h and one of newsworthiness λ_l to be read, we need:

$$m_h\lambda_h + \lambda_l - \kappa \cdot (m_h + 1)\nu_{RD} \geq 0 \iff \lambda_l \geq \kappa \cdot (m_h + 1)\nu_{RD} - m_h\lambda_h.$$

For the story s_l not to be skipped, we need:

$$m_h\lambda_h + \lambda_l - \kappa \cdot (m_h + 1)\nu_{RD} \geq m_h\lambda_h - \kappa \cdot (\nu_{SK} + m_h\nu_{RD}) \iff \lambda_l \geq \kappa \cdot (\nu_{RD} - \nu_{SK}).$$

Combining the two, we get:

$$\lambda_l \geq \max\{\kappa \cdot (m_h + 1)\nu_{RD} - m_h\lambda_h, \kappa \cdot (\nu_{RD} - \nu_{SK})\}, \tag{18}$$

which for $\kappa = 1$ is exactly Condition (8). Given the assumptions of Proposition 1, it is obviously also sufficient.

The maximum number of stories m_l of newsworthiness λ_l that can be inserted, if there are m_h stories of newsworthiness λ_h has to satisfy:

$$m_h\lambda_h + m_l\lambda_l - \kappa \cdot (m_h + m_l)\nu_{RD} \geq 0 \iff m_l \leq \frac{m_h(\lambda_h - \kappa \cdot \nu_{RD})}{\kappa \cdot \nu_{RD} - \lambda_l} \implies m_l = \lfloor \frac{m_h(\lambda_h - \kappa \cdot \nu_{RD})}{\kappa \cdot \nu_{RD} - \lambda_l} \rfloor, \tag{19}$$

which, for $\kappa = 1$, gives exactly Condition (9).

Finally, to see the statement in footnote 13 (after Proposition 1), comparing the Conditions (18) and (19) for $\kappa > 1$ with $\kappa = 1$, it suffices to note that the RHS of (18) is strictly increasing in κ, (implying $\tilde{\lambda}_l > \lambda_l$), while the final expression for m_l in (19) is strictly decreasing in κ, (implying $\tilde{m}_l < m_l$). □

Proof of Proposition 2. We first confirm that the agent's preference is to read exactly one story of topic A and none of topic B. Reading one story of topic A provides utility $\lambda^A - \nu_{RD}^2 > \nu_{RD}^2 - \nu_{RD}^2 = 0$, and so is preferable to reading no stories. It is also preferable to reading $m_A \geq 2$ stories of topic A since $\lambda^A - \nu_{RD}^2 > m_A\lambda^A - (m_A\nu_{RD})^2$ holds if $\lambda^A < \frac{(m_A^2-1)\nu_{RD}^2}{m^A-1} = (m_A + 1)\nu_{RD}^2$. To see the latter, recall that by assumption $\lambda^A < 3\nu_{RD}^2$, and hence $\lambda^A < (m_A + 1)\nu_{RD}^2$ for any $m_A \geq 2$. Reading one story of topic A is also clearly preferred to reading any story of topic B, which always provides a net utility of zero. The reader will also not read any stories of topic A

combined with topic B. This is because, for any $m'_A \geq 1$, $m'_B \geq 1$,

$$m'_A\lambda^A + (m'_B\lambda^B)^2 - ((m'_A + m'_B)\nu_{RD})^2 < m'_A(3\nu_{RD}^2) + (m'_B)^2\nu_{RD}^2 - (m'_A)^2\nu_{RD}^2 - (m'_B)^2\nu_{RD}^2 - 2m'_Am'_B\nu_{RD}^2$$
$$\leq m'_A\nu_{RD}^2(3 - m'_A - 2m'_B) \leq 0,$$

since for $m'_A \geq 1$ and $m'_B \geq 1$, the term $3 - m'_A - 2m'_B \leq 0$.

This shows that the firm cannot induce the reader to reader both his preferred story of topic A and additional stories of topic B. Therefore, if the firm has $m_B > 1$ stories of newsworthiness $\lambda_B = \nu_{RD}$ available, then, if the firm places them first and the reader does not skip them, then the reader will only read those stories and none from topic A. The total utility of doing so for the reader will be $(m_B\nu_{RD})^2 - (m_B\nu_{RD})^2 = 0$, and so the reader would read them by assumption (recall that we assume that when the reader is indifferent, he chooses the plan that is preferred by the firm; alternatively, we could assume that λ^B is slightly above ν_{RD}, which would leave the result unchanged). This is the firm-optimal strategy provided that the reader does not skip these stories to read his preferred one.

Given this, we now show that Condition (10) is necessary and sufficient for this to be the unique optimal strategy. First, we show that the reader will not skip $\widetilde{m}_B < m_B$ stories of topic B to then read the remaining $m_B - \widetilde{m}_B$ stories of topic B and the remaining one of topic A, as his utility would not be positive. In particular, the lower bound of $\nu_{SK} = 0$ allows the reader to skip at no cost. By the previous argument, the reader will still not wish to read both stories of topic B and one of topic A, as his utility will be negative. Hence, for any higher skipping cost $\nu_{SK} > 0$, the reader will not skip some stories of topic B and read others (in addition to A) either, as his utility will be even lower. It remains only to show that the reader will not skip *all* m_B stories to then read his preferred story on A. This is so because it gives the reader a utility level:

$$\lambda^A - (m_B\nu_{SK} + \nu_{RD})^2 \leq (m_B\nu_{RD})^2 - (m_B\nu_{RD})^2 = 0 \iff \lambda^A \leq (m_B\nu_{SK} + \nu_{RD})^2$$

where the latter holds if and only if Condition (10) holds. □

Proof of Proposition 3. To guarantee crowding out, in which all firms place all m_B stories of topic B before topic A, as an equilibrium, it must be that (i) the readers do not have an incentive to switch and (ii) that neither firm has an incentive to deviate (recall that the conditions of the last proposition are taken to hold, implying that the reader will not skip any number of stories of topic B to then read the story of topic A). With regard to (i), since both firms are providing the same strategy over the relevant domain, the reader has no incentive to switch unless a firm changes strategy. With regard to (ii), we first note that the only deviations that a firm would consider is to put the story of topic A first. This is because, as shown in the proof of the last proposition, the reader will never read stories of topic A combined with stories of topic B. Hence by not placing story of topic A first, the firm strictly loses profit.

When a firm places the story of topic A first then this strictly lowers its profit from its original share of the market (M_i), and can therefore only be a profitable deviation if it leads to a high enough capture of the other firm's original share of the market. For this to occur, two conditions need to be satisfied. First, the switching cost must be low enough for the readers of the other firm to switch, i.e., $\lambda^A - (\nu_{SW} + \nu_{RD})^2 < 0$, or equivalently, $\nu_{SW} < \sqrt{\lambda^A} - \nu_{RD}$ (recall that if indifferent, the reader chooses the action that favors the current outlet and does not switch). Second, the deviation profit must be strictly greater than the non-deviation profit, i.e., $1 > M_i m_B$ for firm i, where the LHS corresponds to the deviation profit, and $M_i m_B$ corresponds to the non-deviation profit (share of the market M_i multiplied by number of stories m_B read per reader). Equivalently,

$m_B < 1/M_i$ for each firm i. Note that the first condition above cannot hold if Condition (11) holds, and the second cannot hold if Condition (12) holds. Together therefore, they imply that the crowding-out equilibrium exists. Moreover, if neither of them holds then a crowding-out equilibrium would not exist, since one of the firms will deviate.

Finally, notice that, with a second firm, if Condition (12) does not hold, then the reader-efficient equilibrium exists as well, since the firm which deviates to the crowding out strategy of placing all m_B stories first will lose its market share. However, if Condition (12) does hold, then the only equilibrium that exists is the crowding-out equilibrium. For any other strategy, a firm would deviate to the crowding-out strategy, as the readers would not switch to the other firm, and the firm would obtain a higher profit. □

Proof of Proposition 4. We first show that for $\alpha > \nu_{RD} - \lambda_l$, the same reader-inefficient equilibria remain as the only equilibria. First, under reader-inefficiency (with all m_l stories of newsworthiness λ_l placed before the m_h stories of newsworthiness λ_h), the price set by the firm is:

$$\hat{p}^i = m_h\lambda_h + m_l\lambda_l - (m_h + m_l)\nu_{RD} = m_h(\lambda_h - \nu_{RD}) + m_l(\lambda_l - \nu_{RD}), \tag{20}$$

which is the maximum surplus that it can extract, since it sets the reader's utility to 0. Recall that since we are maintaining the conditions of Proposition 1, the reader would not skip stories in any case. The firm would then obtain a profit of $\alpha(m_h + m_l) + \hat{p}^i$.

Instead, if the firm chooses to only place a subset consisting of $\tilde{m}$ stories of newsworthiness λ_l on top, where $0 \leq \tilde{m} < m_l$, it would set the price:

$$\tilde{p}^i = m_h\lambda_h + \tilde{m}\lambda_l - (m_h + \tilde{m})\nu_{RD} = m_h(\lambda_h - \nu_{RD}) + \tilde{m}(\lambda_l - \nu_{RD}), \tag{21}$$

obtaining profit $\alpha(m_h + \tilde{m}) + \tilde{p}^i$. Given this, the reader-inefficient equilibria remain profit-maximizing if:

$$\begin{aligned}\alpha(m_h + m_l) + \hat{p}^i > \alpha(m_h + \tilde{m}) + \tilde{p}^i &\iff \alpha m_l + \hat{p}^i > \alpha\tilde{m} + \tilde{p}^i \iff (m_l - \tilde{m})\alpha > \tilde{p}^i - \hat{p}^i \\ &\iff (m_l - \tilde{m})\alpha > m_h(\lambda_h - \nu_{RD}) - m_l(\nu_{RD} - \lambda_l) - m_h(\lambda_h - \nu_{RD}) + \tilde{m}(\nu_{RD} - \lambda_l) \\ &\iff (m_l - \tilde{m})\alpha > (m_l - \tilde{m})(\nu_{RD} - \lambda_l) \iff \alpha > \nu_{RD} - \lambda_l.\end{aligned}$$

This is precisely the condition that we have assumed for the case of reader-inefficient equilibria.

If instead $\alpha \leq \nu_{RD} - \lambda_l$, then the reader-efficient ranking is optimal. To see this, note first that the case $\tilde{m} = 0$ corresponds to the reader-efficient ranking, where the m_h stories of newsworthiness λ_h are placed first, and hence, for reader-efficiency, from Equation (21) above with $\tilde{m} = 0$, the price chosen by the firm would be $\bar{p}^i = m_h(\lambda_h - \nu_{RD})$. Therefore, we have that, for any $0 < \tilde{m} \leq m_l$:

$$\begin{aligned}\alpha m_h + \bar{p}^i \geq \alpha(m_h + \tilde{m}) + \tilde{p}^i &\iff \bar{p}^i - \tilde{p}^i \geq \alpha\tilde{m} \\ &\iff m_h(\lambda_h - \nu_{RD}) - m_h(\lambda_h - \nu_{RD}) - \tilde{m}(\lambda_l - \nu_{RD}) \geq \alpha\tilde{m} \iff \nu_{RD} - \lambda_l \geq \alpha,\end{aligned}$$

which is the original assumption made. This concludes the proof. □

Proof of Proposition 5. Suppose first that $\alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$. Then, to see that all equilibria must have the reader-efficient ranking with price $p^i = \lambda^A - \nu_{RD}^2$, note that profits are $\alpha + \lambda^A - \nu_{RD}^2$. The price is the highest the firm can set as it is the maximum reader surplus that can be extracted. If instead the firm provides the inefficient ranking, then its profits are αm_B, since it can at most charge a price of 0. But then

$$\alpha + \lambda^A - \nu_{RW}^2 \geq \alpha m_B \iff \alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1},$$

shows that the efficient ranking is always optimal in this case. (This also shows that, when $\alpha = \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$, then both the efficient and the inefficient rankings can be sustained in equilibrium.)

Suppose now $\alpha > \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$. If Condition (10) holds, then, using the same arguments as in the proof of Proposition 2, it is easy to see that only the crowding-out ranking can be optimal, and again the maximum price that can be charged is $p^i = 0$. Similarly, Condition (10) is also necessary to ensure that readers do not want to skip any of the m_B stories on topic B. □

Proof of Proposition 6. Suppose there are two firms with market shares $0 < M_1, 1 - M_1 < 1$, and that all the conditions of Proposition 2 hold. We distinguish three cases that prove the three statements of the proposition in reverse order.

Case 1. Suppose first that $\alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$. Then to see that all equilibria must have the reader-efficient ranking, suppose a firm provides the inefficient ranking then its profits are $M_i \alpha m_B$. If it switches to a reader-efficient ranking charging just below the monopoly price, then regardless of what the other firm does, its profits will be $M_i(\alpha + \lambda^A - \nu_{RW}^2)$. But then

$$M_i(\alpha + \lambda^A - \nu_{RW}^2) \geq M_i \alpha m_B \iff \alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1},$$

shows that the inefficient ranking cannot be optimal. Given this it is easy to see that all equilibria involve the reader-efficient ranking and, moreover, because of the switching cost, also involve some randomization of prices (that becomes degenerate at $p^i = 0$ when $\nu_{SW} \to 0$). To see that there will be some randomization, notice first that, if both firms charge the monopoly price $p^i = \lambda^A - \nu_{RW}^2$, then the firm with the smaller market share has an incentive to lower its price and attract all consumers. Next, if both firms charge the same price (below monopoly level) $p_1 = p_2 < \lambda^A - \nu_{RW}^2$, then both firms have an incentive to charge a slightly higher price without losing consumers due to the switching cost. Existence of an equilibrium in mixed strategies with respect to prices follows from standard arguments (Dasgupta and Maskin (1986)).

Case 2. First we show that if $\alpha > \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$ and Condition (12) of Proposition 3 hold, then only crowding out equilibriua occur. Consider the firms' strategies in which they each rank the m_B stories of topic B, before the one on topic A, and charge $p^i = 0$. Following the logic of Proposition 3, we know that the readers have no incentive to switch outlet (recall from previous propositions that the readers have no incentives to skip stories to read the one on topic A, or to read the one on topic A after the others). Moreover, even if firms provided the reader-efficient ranking for free, the readers would only switch if $\lambda^A - (\nu_{RD} + \nu_{SW})^2 > 0$, or $\nu_{SW} < \sqrt{\lambda^A} - \nu_{RD}$, which would contradict Condition (12). Concerning the firms, as in Proposition 3, their only possibly profitable deviation would be to put the story of topic A first, because the readers would not read stories of topic A unless it is provided first. Note that the firms would not capture any additional market share. If they were to do so, then they would charge all the net utility surplus, which is $\lambda^A - \nu_{RD}^2$. Hence, this would be a profitable deviation only if $M_i(\alpha + (\lambda^A - \nu_{RD}^2)) \geq M_i \alpha m_B$, noting that the price must be 0 if the firms do not deviate, since the readers have 0 net utility. But this holds only if $\alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$, which contradicts our condition above. Hence, firms have no incentives to deviate, and so the crowding out ranking is indeed an equilibrium, with price set at 0, since the reader's net utility is 0. Moreover, note that there can only be crowding out equilibria, since the firm makes higher profit, and so for any reader-efficient ranking, the firm would have an incentive to deviate to the crowding out ranking.

Second, we show that if only the crowding out equilibria occur, then $\alpha > \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$ and Condition (12) must also hold. Recall from Case 1 that $\alpha \leq \frac{\lambda^A - \nu_{RD}^2}{m_B - 1}$ implies that an efficient equilibrium always exists. To see that also Condition (12) is necessary, recall the argument from Proposition 3 above that if (12) does not hold, then again the efficient ranking is sustainable as the deviating firm would lose its market share.

Case 3. Given the above, it remains to show that, if $\alpha > \max\left\{\frac{\lambda^A - \nu_{RD}^2}{m_B - 1}, \frac{\lambda^A - \nu_{RD}^2 - \nu_{SW}}{m_B M - 1}\right\}$, then a crowding out equilibrium always exists. In particular, we only need to consider the case when Condition (12) does not hold, since the other case was already treated above. Note that without Condition (12), there is no longer a guarantee that readers would not switch if firms change strategy. Suppose that a firm does switch from providing a crowding-out ranking to providing the reader-efficient one. For the readers to switch, the highest price that the firm can charge must be such that the reader obtain at least 0 (this is the net utility of not switching). That is, $\lambda^A - (\nu_{RD} + \nu_{SW})^2 - p_i' = 0$, and so $p_i' = \lambda^A - (\nu_{RD} + \nu_{SW})^2$ (note that since Condition (12) does not hold, $p_i' > 0$). The firm would then obtain all the market, and it will be a profitable deviation (we only consider the firm with the smallest market share $M = \min\{M_1, 1 - M_1\}$, which will have the more binding condition) if $\alpha + p_i' = \alpha + (\lambda^A - (\nu_{RD} + \nu_{SW})^2) \geq \alpha m_B M$, or, rearranging, $\alpha \leq \frac{\lambda^A - (\nu_{RD} + \nu_{SW})^2}{m_B M - 1}$. This violates the condition above. Hence, the crowding out equilibrium exists, and again the price is set at 0. □