Consumer Favorites and The Design of News

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Abstract

The objective of this paper is to better understand the factors that competitive news providers consider to design or deliver news programmes. The focus is broadcast news where in any programming time period, a viewer watches (or consumes) one programme. We assume that each viewer is interested in a limited set of topics and that her utility only comes from the "most interesting" news she observes. The key questions we address are a) should firms adopt designs that facilitate the delivery of more information in their news programmes, b) does the decision of firms to implement such strategies depend on the complexity of the news programme (i.e. the number of news stories covered in the news product) and c) how do such strategies influence competition. We show that firms may or may not benefit by providing better designed news. The incentive to do this is strongly affected by the complexity of the news product and the intensity of competition between news providers.

Keywords: Information processing, media competition, game theory.

1 Introduction

The role of news providers is to inform the public about significant events that occur each and every day. In an average day, US consumers have access to more than 100 news reports from prime-time TV news programmes and at least 20 stories from the front page of major newspapers (Holcomb et al. 2011). Despite this wealth of information, the reality is that the average consumer is interested in a limited number of topics. A consumer watching 'CNN Today' might only be interested in the news about French economy and not the news about Syria or the election in Kenya.

This phenomenon is highlighted by a weekly news survey conducted by the Pew Research Center to assess the level of match between the interest of news consumers and the news that is actually reported. Invariably, this survey identifies a significant degree of mismatch between the interest of consumers and actual news coverage. A typical example of this mismatch is found in the weekly survey of March 28, 2011 to April 3, 2011 (see Figure 1).

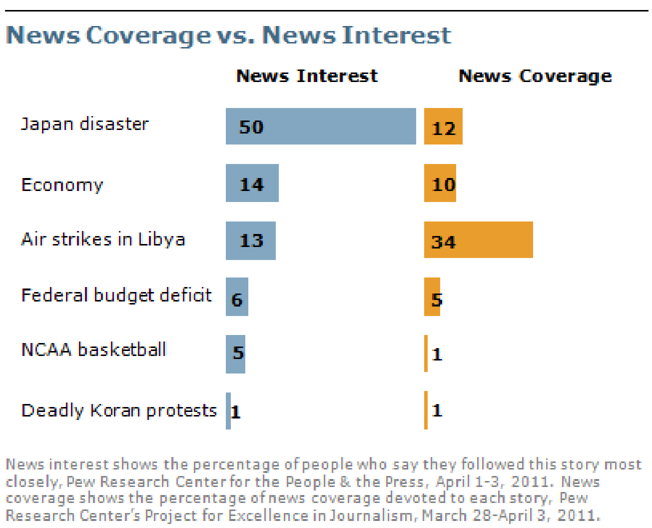

Figure 1: Mismatch between news interest and news coverage (Pew 2011a)

The first column shows that there is significant heterogeneity in what consumers want to see and suggests that news viewers do not value all stories equally. Viewers are looking for certain types of stories when they consume the news (on TV, on radio or in newspapers) and it is difficult to know in advance what viewers want. The second column shows that despite the best guesswork of the networks, news consumers "do not always get what they want." This may come from the fact that there is substantial uncertainty in the production of news. On any given day, neither consumers nor news providers know if there will be 'news-worthy' stories that are consistent with the interests of news consumers. In our analysis, we reflect this uncertainty by assuming that competing news providers receive independent draws from a continuum of potential news stories.[1] In this context, it follows that a mismatch of news preferences and news provision might be an important driver of news programme selection.

Our goal is to examine how the two factors (the uncertainty associated with news production and the heterogeneity in consumer favorites) affect the structure and design of news in a competitive environment. This is important as programme production is a critical activity for news providers associated with substantial investments. For example, CNN and Fox News Channel spent $285 million and $464 million respectively on programming in 2009 representing 44% and 72% of their total spending (Holcomb et al. 2011).

The model we propose reflects the idea that consumers have favorite stories by assuming that consumer utility is solely driven by the news story (or news item) that each consumer finds to be the "most interesting". The approach we take is to represent each news programme as a set of information. The challenge of "design" for the news provider is one of modulating the quantity and form of information that is presented to news consumers.

News providers can design programmes such that the amount of information transmitted to consumers is high. This is often achieved by the formatting and modularization of stories, editing and the reporting style (Hamilton 2003). For example, Fox and CNN, two of the world's top news providers, are characterized by highly refined programming that presents information in bite size chunks that can be processed easily (or viewed) by a person who has limited time to watch the news. Reporting styles also include the use of harmonious music and sound and consistent and visually pleasing graphics. These elements of news programmes can make the news more entertaining and this tends to increase both audience attention and retention. When asked about the change of its background music, Geoffrey Darby, the Weather Channel's new executive vice president of programming, said, "We wanted music that would get their attention – and this has." Research in psychology and consumer behavior shows that consumers are more efficient processors of information when their attention is high (Fabrigar and Petty 1999, Payne et al.

[1]We thank an anonymous reviewer for highlighting the limitations of this assumption in a context of blockbuster news stories. We discuss this issue further in Section 2.

1988, Petty and Cacioppo 1986, Tsai and Thomas 2010). In other words, better reporting styles facilitate information processing by viewers, thus making the information or the content of news more informative. In a way, the design of news programmes is similar to that of a professor designing a class: the professor needs to decide the amount of information to include in the class and package and deliver it in a way that is both simple and interesting.[2]

Our focus will be how the design of news programmes affects the consumption of news stories and consequently consumers' news choices. We examine this issue in a context where three elements are varied. The first is the complexity of the news product (the number of news stories in the news product), the second is the impact of competition on the attractiveness of such strategies, and the final is the quantity of information per news story.[3]

Intuitively, assuming that the cost is sufficiently low, one would expect that a news provider would always benefit from a news programme that is better designed and delivered. However, we show that better design can "hurt" a news provider when the number of news stories in a programme is small. Our analysis, which is based on the concept of mismatch between the interests of news consumers and actual news coverage, shows that improvements in programme design lead to reduced demand when the number of news stories is low. In contrast, when competing programmes have a significant number of news stories, there is no substitute for "good design". Here, a news provider that tries to compensate for poor design by increasing the number of stories will be at a disadvantage to a competitor that has better design.

Our paper is organized as follows. In the next section, we present our model. We then analyze a simple case of news design and delivery and consumer favorites in the third section. We also examine a general model of news design and competition and discuss its implications for news providers. We conclude in Section 4.

[2]It is worth noticing that our conceptualization of news design only focuses on the amount of information (not the type of information) packaged and transmitted to the consumers. In other words, we do not examine the selective reporting and slanting of information, which leads to media bias (Gabszewicz et al. 2001, Mullainathan and Shleifer 2005, Xiang and Sarvary 2007).

[3]The complexity of the news product (i.e. the number of stories in the news product) is generally related to its length. A 10 minute "top of the hour" news update will be less complex by definition than the "The World Today" on CNN which lasts for 60 minutes.

2 The Model

We present the model in three building blocks. First, we outline our approach to representing news products. Second, we discuss how the information contained in news products is processed by consumers. Finally, within this context, we present the strategies that competing news providers can adopt and show how these strategies affect profits.

2.1 News Products

A fundmental assumption of the model is that there is substantial randomness in the stories included in news programmes even though news providers go through a careful process of selecting which stories to report. It is true that news providers choose the subject area for their programme in advance. But within the subject area, there is significant randomness in the events that occur.[4] Thus, events are assumed to be generated exogenously and not controlled by news providers. When an event happens, a news provider can report the event assuming it has staff on site to provide a report. To be specific, an event is described by a random variable, uniformly distributed over [0, 1]. One can think of the 0-1 continuum as the range of possible stories that might be reported in a subject area. Each event is associated with a specific point 'w' and one can think of this as the location of the news story. In reality news stories have many dimensions. In our model, we simplify the world and assume that there is only one.

It is important to note that our model focuses on competition between news providers who target their news programme towards the same segment. In other words, each competitor in the model draws news from the same potential basket of stories. We further assume that the draws by the news providers are independent. This independence assumption may be stretched when a major news story breaks (such as a terrorist attack or an earthquake).[5] However, aside from the case of a major blockbuster story, each news provider has its own set of stories to report.[6] The

[4]We admit that the assumption of randomness is challenged when news providers selectively choose stories to achieve a 'reporting stance'. For example, a left-wing newspaper may choose not to report the success of a conservative policy. Naturally, this manner of selective reporting leads to media bias. Our desire is to abstract away from this phenomenon and model a market where news providers are unbiased providers of information that consumers want.

[5]A recent article highlights a significant departure from normal viewing habits when there is a terrorist attack, a natural catastrophe or a war to report ("Unbiased and unloved", *The Economist*, September 22, 2012, p.72).

[6]In a sense, the model applies to a "slow night" for national or international news or a "typical night" for local

reason there is significant overlap but also difference between competing programmes, is that news providers assess the 'news value' of different stories independently and thus incorporate different stories into their programmes. It is important to remember that the model we propose is one of how consumers make choices. If major news stories tend to be reported in the same way using similar video feeds (that even come from the same camera), the major stories may not be diagnostic in determining how viewers make choices (the competing products may be the same when it comes to thinking about major stories). It may be that secondary stories (the local news as highlighted in our paper) are the determining factor in how consumers make choices, in which case, the assumption of independent w's may be less unattractive than it seems.

We also assume that news providers cannot report 'w' directly to the public. Rather, they report what they observe with regards to the event, i.e. signals about the actual value of 'w'. To be specific, we assume that each piece of news contains a series of Bernoulli signals, denoted by $s_i \in \{0, 1\}$ ($i = 1, 2, 3, ...$), relating to the event 'w'. Since $w \in [0, 1]$, and s_i is the signal about w, we assume that $\text{Prob}(s_i = 1) = w$, and s_i and s_j are independent *conditional* on w. This information structure implies that when w is closer to 1 than 0, then the likelihood of there being more signals of 1 ($s_i = 1$) exceeds 50%. Notice that s_i is exogenously generated by the event w.[7]

To give the model life, we move to a specific example and discuss how the model might represent it. Consider news reports about a flood in a small town in Ontario.[8] A key attribute that might interest viewers with regards to the story is the magnitude of the actual damage (w). In a news story about the flood, there is information (signals s_i) including pictures of the debris, video footage of the flood, interviews with citizens and involved organizations, and statements from the government. The viewer uses this information to generate an estimate $\hat{w}$ of the actual damage. In

news.

[7]The Bernoulli setup is consistent with the news market literature (Mullainathan and Shleifer 2005, Xiang and Sarvary 2007) yet it is not an ideal representation of news which, with all its nuances, would be better represented by a continuous function. However, a degree of simplification is needed to represent how a consumer processes news. As long as one accepts that viewers watch the news in order to learn more about the "real state of the world", the binary representation of information in news programmes is nothing more than an abstraction of how information is transmitted to viewers. Another way to think about this is that the information collected by news agencies is generated by the actual state of affairs but it is never more than a partial representation of exactly what happens. In fact, the conditional independence of the Bernoulli signals suggests that different pieces of information in a news report reflect different aspects of the actual event and they are all related to w (thus correlated with each other).

[8]This example is loosely based on a news story that occurred in April 2008 in northern Ontario.

sum, the model represents how a news product provides information to viewers about individual stories. This information is the basis for how viewers understand each story. In the next section, we explain how this understanding creates utility for viewers.

2.2 News Consumption

To represent the manner by which viewers choose and consume news products, we make the following assumptions. First, we assume that a consumer's understanding of 'w' depends on how much information she processes from the news story: it is a function of her estimate $E(w|s_1, s_2, ...)$. The consumer does not know the precise location of the event w but she reaches a better understanding of the event by processing more information. Consider a viewer who wants to know more about the long term impact of the Japan nuclear crisis. She can follow various news reports to gain a better understanding of the consequences but she cannot know with 100 % certainty what the long term impact will be. In our model, the information consumers process is a function of how many signals are transmitted by the news report. The central argument is that a better designed news programme allows more information to be transmitted to the audience. Consequently, consumers receive and process more information when news is packaged carefully either because the information is easier to understand or because it is easier to pay attention to the programme.

In a nutshell, we assume that in the absence of investment in design and presentation, the news is presented in an unstimulating way and less information is transmitted to viewers. More precisely, we assume that each consumer processes m signals from programmes with low investment in design. In contrast, when the news is well designed, each consumer receives more information and processes twice as many signals ($2m$) from the same content.

An alternate way to conceptualize the impact of superior design is to assume that it allows consumers to obtain more (deeper) information from the same "raw material". A mechanism that captures the notion of deeper processing is to assume that programmes with low and high investment in design deliver the same number of signals; however, well-designed programmes provide (more informative) binomial signals and undesigned programmes provide (less informative) Bernoulli signals. Under this mechanism, deeper processing is equivalent to the processing of more information.[9]

[9]Each binomial signal, denoted by τ_i, can have three values: $\tau_i \in \{0, 1/2, 1\}, i = 1, \ldots, m$. If the probability distribution of τ_i is as follows: $P(\tau_i = 1) = w^2$, $P(\tau_i = 0) = (1 - w)^2$, and $P(\tau_i = 1/2) = 2w(1 - w)$, the binomial

The process of collecting information and aggregating it for consumption has links to the literature on the bundling of information goods (Bakos and Brynjolfsson 1999, 2000). Nevertheless, news bundles have a distinct feature compared to products which are the focus of the bundling literature: in general, a consumer does not pay attention to all the stories (or items) within a news bundle. Often, a significant fraction of news stories within a programme are of little interest to the viewer and she focuses her attention on a limited number of stories. One can think of a consumer's decision to watch a programme as a search for information on the topics that interest her. A consumer may watch 'World Business Today' on CNN, but be primarily interested in the upcoming public offering for Facebook. Another may tune into CNN Today but be primarily interested in the most recent events that took place in Congress. This pattern of news consumption suggests that a consumer's decision to choose a news programme does not depend on extracting value from each and every story in the programme. On the contrary, it suggests that a consumer's reason to view a programme is to find stories that are personally relevant.

We reflect this aspect of news consumption by assuming that a consumer watches a news programme to find stories that best interest her and is unaffected by less interesting stories. In fact, the previously mentioned Pew Research Center survey contains data showing that almost half of consumers are unaware of key stories (even those that figure prominently in the headlines). A sample of this phenomenon from early April 2011 is shown in Figure 2.

Research in psychology shows that people sometimes behave as if they have limited memory: they do not recall all of the information to which they have been exposed. More specifically, the observation that news consumers retain a limited number of news stories echoes findings with regards to 'selective retrieval', i.e., consumers exhibit better recall of information that is relevant to the goal or interest they have at the time of exposure (Anderson and Bower 1973, Bower et al. 1981, Wyer and Srull 1989).[10]

distribution is "logically consistent" with the Bernoulli signals that follow $\text{Prob}(s_i = 1) = w$. This conceptualization is a direct representation of deeper processing by consumers. Interestingly, it is identical in terms of estimation to processing twice as many Bernoulli signals from the same information, i.e., $E(w \mid \tau_1, \tau_2, ..., \tau_m) = E(w \mid s_1, s_2, ..., s_{2m})$.

[10] The advantage of incorporating concepts from consumer psychology into models of competition is that the model insights are based on both profit maximizing behavior (by firms) and a research-based representation of consumer behavior. For example, Iyer and Kuksov (2010) study how consumers' processing of quality signals can be influenced by a firm's investment in affect related activities and Chen et al. (2010) explore the impact of consumers' memory

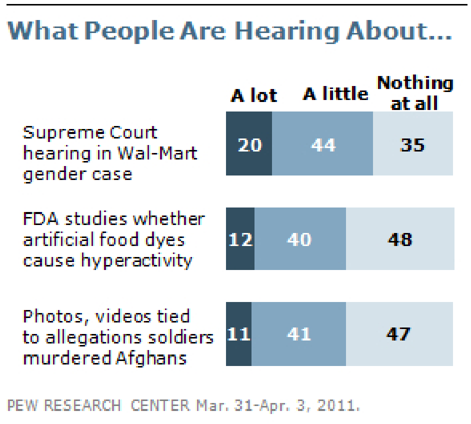

Figure 2: Consumers unaware of reported news (Pew 2011b)

In sum, we find significant evidence to support the idea that many news stories have no effect on any individual viewer; irrelevant reports are often forgotten. This provides justification to incorporate consumer favorites into a model that strives to explain how news providers design products.

Consumer preferences, denoted by x, are uniformly distributed between 0 and 1, i.e., $x \sim U[0,1]$. In our model, each consumer makes a decision to consume one news programme. We assume that there are 'n' stories within a news programme, and we denote by 'B' the set of events that are covered in the programme. Furthermore, we assume that a consumer's sole interest is her favorite news story. In this setup, the favorite news story can be thought of as the news *item* that is closest to the consumer's preference point. Consumer utility depends on the distance between the consumer's preference point and the closest news *item*. A consumer with preference point at x obtains utility of:

$$u = R - \min_{\forall w_j \in B} \{\mid x - E(w_j \mid m) \mid\}, \tag{1}$$

where $j = 1, 2, ..., n$, R is the overall utility of consuming one news programme and x is the consumer's preference point. The last item represents the disutility a consumer incurs by not finding the information that perfectly matches her preference, i.e., by not viewing a news story that is as close as possible to her favorite topic.

An implicit assumption of this utility function is that the consumer searches (processes) every story in the news programme to find her favorite piece of news. As discussed earlier, this perspective

capacity on price competition.

is consistent with research in psychology related to the manner by which individuals interact with the environment to find information that is personally relevant or important.

When a consumer chooses between competing news programmes, she assesses the comparative likelihood of getting a story that is as close as possible to her preference point. Notice that news is an experience good and consumers do not know the location of the news prior to consumption. Thus, the actual utility a consumer obtains from a news product is unknown until a) she sees the programme, b) processes the signals in each news story and c) derives enjoyment as a function of how close the "best story" is to her ideal point. The interesting aspect of this process is that the viewer needs to make a choice about which programme to watch before she sees it. Thus, she makes her choice based on her expectations about the news programme. This is largely driven by the number of news stories that are included in the programme and the "design" that the news provider has adopted for the programme (which the news consumer knows *ex ante*).

Equation (1) implies that a consumer derives utility solely from the story closest to her preference point. That is, each consumer looks for her favorite news story and is unaffected by stories which are farther away from her ideal point than the favorite. Because our model is based on a situation where a consumer only has *one* favorite news story, for robustness, it seems important to demonstrate that the findings extend to contexts where viewers have more than one favorite. Accordingly, we present a simplified model in the Appendix where consumers have *two* favorites and show that the results hold. Multiple favorites can be thought of as a special case of product attributes/utility mapping (Tversky 1972) and is consistent with the literature on determinant attributes (Alpert 1971). We acknowledge that our analysis has limited application to a market where the primary interest of viewers is to obtain a comprehensive summary of everything that is reported.[11]

2.3 News Providers

Each news provider is assumed to have the capacity to collect and incorporate n pieces of news into its programme. News providers then choose their effort in designing the news programmes. This includes the packaging of the information and/or the adoption of a viewer friendly design. We

[11] Later in the paper, we show that better design leads to a higher number of locations for possible news stories. As the number of favorites increases, better design dominates because the likelihood that a consumer finds multiple favorites is higher when more locations are provided in a programme.

denote e as the design effort of the firm. When a firm exerts high effort in news design, denoted by $e = H$, a cost k is incurred and more signals are transmitted to the audience in the news programme. As explained earlier, with high effort in news design, the audience receives $2m$ signals from each news story. When a news programme is not packaged or refined, we categorize this as putting low effort into design, denoted by $e = L$, and the cost associated with the low effort is normalized to 0. In this situation, the audience only receives m signals from each news story.

We also assume that the design strategy of news providers (in terms of staffing, modularization, and packaging) is a strategic decision. In contrast to news stories which change every day, the manner by which the news is presented to the audience tends to be stable. The following is an explanation for why we model the design strategy of news providers as being strategic. First, setting up a news bureau and the hiring and training of staff takes time. In fact, there seems to be a high level of stability in the journalists that work with networks (or programmes) over time. Second, many elements of news programmes (such as the format, the features, the script, the style of the supers and the timing of breaks) change rarely. This stability is exemplified by the background music at the Weather Channel. While the music was recently replaced, the "replaced" version had been played for years prior to the change.[12] These observations support the idea that news providers make news design decisions long before the realization of the daily/hourly news (it is the first decision in the set of decisions taken by news providers).

There are different media revenue models in the literature: Gabszewicz et al. (2001) propose that media firms' profit comes solely from advertising revenue. Xiang and Sarvary (2007) and Mullainathan and Shleifer (2005) present media models of the price-demand interaction. Godes et al. (2009) examine content and advertising revenues for competing media firms. Falkinger (2007) argues that media firms strive to maximize the impact of media and focuses on the impact of news design on consumer news choice. Our objective is to analyze the informational aspects of news provision and this perspective follows Falkinger's (2007) impact model, which assumes that news providers try to maximize audience size: $\pi = \gamma D$. One can think of γ as the rate per viewer that news providers charge for advertising. Firms are assumed to maximize *ex ante* expected demand because this allows the firms to maximize the revenues earned from advertising.

[12]The old sound was so popular, the network released a CD of "Weather Channel Smooth Jazz" that went to No. 1 on Billboard's Current Contemporary Jazz Album Chart.

3 Analysis

In this section, we start with a simple case of monopoly news provision to illustrate the mechanism that underlies the general model. We show how the simple model applies to news design and we use it to demonstrate the strategic value of a well designed news programme. We then move to a setting where two news providers compete to maximize their respective shares of a media market. A general model is provided at the end of the section.

3.1 The Simple Monopoly Model

In the simple case, we focus on the monopolist's decision to design the news in a world where there are n news stories in the programme and each news story contains a maximum of two signals ($m \leq 2$). The simple case allows us to highlight the key effects of news design on the choices that consumers make.

3.1.1 Consumers Processing

When a news provider makes low investment in the design and delivery of its programme, suppose only one signal is transmitted to consumers for each story in the news programme. In contrast, when a firm decides to refine its presentation and present the news in a well designed fashion, consumers receive two signals per news story. This simple setting is useful to understand the impact of news design, and it reflects the practice that some providers employ of presenting the news as a series of short condensed "bite-size" reports. A prototypical example of this format is CNN's Headline News. Note that in a simple format like this, the "signals" help news consumers to obtain a general idea about what has happened. To gain a deep understanding, a consumer needs more signals about the event in question. Further discussion of the difference between signals and news stories is provided in the general model, which is a *more* realistic representation of the news market.

A consumer can not directly observe w_j ($j = 1, 2, ..., n$) by watching the news. Rather, she processes the information in the news to reach a rough estimate of the actual location of the news story, denoted by $\hat{w}_j$. If the firm does not present the news in a well-designed fashion, then consumers observe one signal per news story, where $s_j = 1$ or $s_j = 0$ ($j = 1, 2, \ldots, n$). If $s_j = 1$ is observed, then the estimated location of w_j is $2/3$, and if $s_j = 0$, then the estimated location of w_j

is 1/3.[13] We have:

$$\begin{cases} \hat{w}_j = 1/3 & \text{if } s_j = 0, \\ \hat{w}_j = 2/3 & \text{if } s_j = 1. \end{cases} \tag{2}$$

Notice that when $s_j = 0$, a consumer's understanding of the event $\hat{w}_j$ is not 0, but rather 1/3. This obtains because one signal (in this case, $s_j = 0$) does not reveal the actual location of the news story: it only provides an indication of the actual location. Given the limited amount of information in the news, a consumer accounts for her prior beliefs about the location of the news $w \sim U[0, 1]$ in order to interpret the signal and update her belief about the actual location. A uniform prior plus a Bernoulli signal of 0 leads to a posterior belief of w in a Beta distribution with a mean of 1/3.

If the firm makes high investment in news design and delivery then consumers process two signals (s_{j1} and s_{j2}) for each news story (w_j). With respect to the estimation of $\hat{w}_j$, given two signals, we have:

$$\begin{cases} \hat{w}_j = 1/4 & \text{if } s_{j1} = s_{j2} = 0, \\ \hat{w}_j = 1/2 & \text{if } s_{j1} \neq s_{j2}, \\ \hat{w}_j = 3/4 & \text{if } s_{j1} = s_{j2} = 1. \end{cases} \tag{3}$$

Comparing Equation (2) and (3), we see that well designed news leads to a broader distribution (in terms of the estimated location for the news story as a function of the signal received by the consumer). Notice that these estimated locations, i.e., $\hat{w}_j$ are the possible "expected" outcomes for the expected location of the event after a consumer has watched the news story.

A consumer will watch the news programme from the monopolist if and only if her utility is greater than zero. Using the utility function specified in Equation (1), this implies that:

$$\text{Prob}(\text{watch } B) = \text{Prob}(\min_{\forall w_j \in B}\{\mid x - E(w_j \mid m) \mid\} < R). \tag{4}$$

In summary, a consumer makes a news consumption decision *ceteris paribus* based on one factor: the probability of viewing a news *story* that is close to her preference point. Imagine the situation of a consumer whose ideal news story is located at 1/2. If she watches a well-designed news programme, she will be able to process two signals per news item. If the two signals are different

[13] See Appendix for proof.

($s_{j1} \neq s_{j2}$, then her understanding of the event is 1/2 ($\hat{w}_j = 1/2$), and she will be delighted: this is exactly what she wants (her ideal point is $x = 1/2$). However, she is far from certain to receive such a signal combination. She may also receive two signals of 1 or two signals of 0 which are clearly less encouraging (the former leads to $\hat{w}_j = 1/4$, and the latter leads to $\hat{w}_j = 3/4$). In other words, there is a chance that the consumer will encounter a news item that is discouraging.

In contrast, if she watches the news programme which is not well-designed, then the her information processing leads to an estimated location at either 1/3 or 2/3 (a priori, there is a 50 % likelihood of seeing each signal combination). Interestingly, either of these signal combinations is preferred to the discouraging signals from the well designed news programme. In the example above, a consumer at 1/2 prefers the poorly designed news programme compared to the well designed programme! We show in the following section how this probability directly influences the expected demand for the news provider.

3.1.2 The News Provider's *ex ante* Expected Return

Consumers make decisions based on beliefs they develop about the content of the news, knowing in advance, the format of news programme in terms of its design and delivery. Accordingly, the news provider assesses the *ex ante* expected return from alternative design strategies given the uncertainty of the world ($w \sim U[0, 1]$).

Let us focus our attention on the case where R is not too high i.e., where $R < 3/4$. This allows us to focus on an important tradeoff that consumers consider in the case of monopoly: to buy or not to buy.[14] We denote by π_L and π_H the profit of the monopolist when its design effort is $e = L$ or $e = H$ respectively. For ease of exposition, we assume that the cost of better design (k) is small. All proofs are provided in the Appendix.

Proposition 1. *In the simple case of one or two signals per news story, the monopolist firm chooses*

[14] From Equation (4), we know that when $R \geq 3/4$, consumer utility is greater than zero. This means that all consumers watch the news programme with probability one. In this situation, there is no tradeoff so the monopolist has no incentive to invest in better design of its product; the additional expense does not bring any benefit.

the design strategy that maximizes profit:

$$\begin{cases} when\ R < \dfrac{1}{4}, & \pi_L \leq \pi_H,\ \forall n, \\ when\ \dfrac{1}{4} \leq R \leq \dfrac{2}{3}, & \pi_L \geq \pi_H,\ if\ n < f(k,R), \\ when\ \dfrac{2}{3} < R \leq \dfrac{3}{4}, & \pi_L \geq \pi_H,\ \forall n, \end{cases} \tag{5}$$

where $f(k,R)$ is the threshold defined by k and R.

To provide intuition for the results, we first note that in the range of interest for R ($R < 3/4$), Proposition 1 identifies three zones. The first is $R < \frac{1}{4}$; R is small. The second is $\frac{1}{4} \leq R \leq \frac{2}{3}$; R is in an intermediate range. Finally, we describe the third zone, $\frac{2}{3} < R \leq \frac{3}{4}$ as one where R is high. To facilitate the discussion, we first consider the zone where R is low. We then discuss the zone where R is high. This allows us to provide intuition for the findings in the intermediate zone which we discuss last.

Proposition 1 indicates that better design dominates a plain style of news delivery in the zone where R is small. In this zone, a well designed news programme transmits more information to consumers and this leads to a more precise estimate of each news story's location. A flatter distribution of locations (denoted by $\hat{w}$) increases the likelihood that a consumer finds a story that she will consume. The biggest problem for the news provider when R is in this range is that many consumers do not buy. Unless a consumer finds a story close to her ideal point she does not buy (R is too low if the travel costs are substantial). Thus, better design provides an overwhelming benefit when R is low by increasing market coverage.

Interestingly, a better designed news programme reduces profits for the monopolist when R is large. In this zone, a consumer is always satisfied with a programme that has a plain design because a story at 1/3 or at 2/3 brings her a positive utility (these are the two possible locations for a news story when there is only one signal per story). In other words, plain design in this zone leads to complete coverage for the monopolist (i.e. demand equals one). In contrast, if the programme is well designed, a consumer at 0 may be unhappy with a story at 3/4 because that story does not deliver positive utility. Similarly, a consumer at 1 might be unhappy with a story at 1/4. Therefore, when R is high, a well designed programme is associated with a non-zero probability that some consumers do not consume the programme; this implies that the expected demand is less than one.

This highlights an important effect of news design. A better designed programme leads to consumers receiving more information on each news story. This leads to more estimated locations of news stories ($\hat{w}$) and these estimates are evenly distributed along the 0-1 continuum. Accordingly, when there are more locations, some of the estimated locations are far away from the ideal points of consumers located on the opposite half of the market. This can lead to negative utility for distant consumers and a decision to not consume.

When R is in the intermediate zone, the overall impact of better news design depends on the relative importance of the two countervailing effects highlighted above. The first is minimizing the distance between the estimated location of the news story and each consumer along the market. The second is avoiding a situation where news stories located close to either end of the linear market lead to some consumers not buying. Not surprisingly, the importance of these two effects is a function of how many news stories there are in the programme. Because consumers are looking for their favorite news stories in the programme, better design is optimal when there are many stories; the reason is that a situation where all news stories are located close to one end of the market is unlikely when the number of stories is high.

The monopoly case helps to highlight the basic mechanism that affects consumer decision making in a market for news products. It also allows us to demonstrate how superior news design affects the decisions of consumers in a market where each consumer looks for her favorite story. It is important to note that the focus in a monopoly market is the consumer's choice to either consume or not. As a result, the monopoly model is interesting if and only if the reservation price is sufficiently low to make this relevant.[15] In the next section, we examine a competitive duopoly and assume that the reservation price is sufficiently high such that all consumers consume. Thus, the relevant question in the competitive market is not whether the consumer consumes (or not) but which of the two news programmes she consumes.

3.2 Simple Case with Duopoly

In the duopoly model, both firms are assumed to have n pieces of news (or stories) in their news programme B_i ($n_1 = n_2 = n$). We continue with a simple case where either one signal (low

[15] We abstract away from pricing in our discussion. In a market where the monopolist chooses a price for its product, the reservation price can be implicitly manipulated by a monopolist i.e., when the price is set high, the monopolist indirectly reduces the reservation price.

investment in design) or two signals (high investment in design) are provided in each news story.

When both firms choose the same design effort, a consumer's *ex ante* probability of choosing either news bundle is 1/2 independent of her location x. When the two firms choose different "design strategies" (i.e. $e_i = H$ and $e_j = L$), the location of the consumer matters.

In choosing a news programme, we assume that consumers understand the difference between "unprocessed" and "highly processed" news i.e. they understand that the distribution of $\hat{w}_j$ is flatter (and more precise) when they watch "highly processed" news. If a consumer consumes undesigned news, then her understanding of the event is either $\hat{w}_j = 1/3$ or $2/3$. If a consumer chooses well-designed news, then her understanding will be $\hat{w}_j = 1/4$, $1/2$ or $3/4$. Said differently, the news consumer understands that uncertainty is associated with viewing news programmes.

Recall that when a consumer chooses a news programme containing multiple stories, she is concerned with finding her favorite story (i.e., the best located story affects the consumer's consumption utility). Thus, a consumer's probability of choosing programme B_i depends on the probability of the consumer finding a story closer to her preference point in B_i. This leads to the following expression:

$$\text{Prob(consume News Bundle 2)} = \text{Prob}\left(\min_{\forall w_{1j} \in W_1} \{|x - \hat{w}_{1j}|\} > \min_{\forall w_{2j} \in W_2} \{|x - \hat{w}_{2j}|\}\right). \qquad (6)$$

The probabilistic choice setup highlights an important aspect of our model: consumers do not choose a programme by comparing the expected utilities from the competing programmes, rather they form an *ex ante* probability of choosing one news programme or the other. To be specific, this means that if a consumer located at zero knows that one news programme is likely to have news items at 0.1 and 0.101, and the alternative has items at 0.1 and 0.9, she is more likely to choose the first programme than the second. Because a consumer's preferences for news programmes depends on the location of her ideal news story, each news provider accounts for the purchase probabilities of all consumers along the preferred story continuum to estimate expected demand. Different "design and delivery" strategies for the news leads to different levels of expected demand. In the simple case, we divide the linear market into eight segments ($x \in [0, 7/24), [7/24, 10/24)$, $[10/24, 11/24)$, $[11/24, 1/2)$, $[1/2, 13/24)$, $[13/24, 14/24)$, $[14/24, 17/24)$, and $[17/24, 1]$). Each of these segments has distinct preferences as a function of the design strategy employed by the news providers.

Segment 1: $x \in [0, 7/24)$

For a consumer located to the left of 7/24, her preference for the news items is:

$$1/4 \succ 1/3 \succ 1/2 \succ 2/3 \succ 3/4. \tag{7}$$

Notice that the estimated news locations 1/3 and 2/3 come from News bundle 1, while 1/4, 1/2 and 3/4 come from News Bundle 2. Furthermore, Equation (7) reflects the consumer's preference at the news *story* level, but we need to describe the consumer choice between alternative news *bundles*, (i.e. programmes). Each programme contains multiple (i.e., n) news *stories*. If a consumer chooses News Bundle 2, she knows that the expected location of each news story will be 1/4, 1/2 or 3/4 (with equal probability). However, due to the random nature of news, she does not know what signal she will obtain before actual consumption. In other words, although she may prefer news at 1/4, she is not sure bundle 2 will have such news and she may well end up with 1/2 or 3/4. Thus she has to rely on the probabilistic distribution of the estimated news locations to choose a preferred programme.

For the ease of exposition, we focus attention on the expected demand for Firm 2 which makes high investment in designing and delivering its news programmes. If Firm 2's news programme contains an story at 1/4, then all consumers between 0 and 7/24 will choose Firm 2 because the best possible news story from Firm 1 is at 1/3. A news story at 1/3 is strictly dominated by one at 1/4 for consumers whose location is at $x < 7/24$.

However, given the random nature of news stories ($w_{ij} \sim U[0,1]$), there is a probability that Firm 2 may not deliver a news story at 1/4. In this case, Firm 2's demand depends on whether its competitor, Firm 1, delivers a news story at 1/3. If Firm 1's programme contains such a story then Firm 1 is preferred by all consumers in the $0 \leq x < 7/24$ segment.

If Firm 1 does not have a story at 1/3, then Firm 2's demand further depends on whether its news bundle contains a story at 1/2 or not. If yes, then all consumers will choose Firm 2; if no, then all news stories from Firm 2 are at 3/4 and all consumers in the segment will choose Firm 1 (the most disadvantageous signal from Firm 1's news is 2/3 which is strictly preferred to a news story at 3/4). Combining the consumer choice and the probabilities of the above events, we compute the segment's *ex ante* probability of consumers choosing News Bundle 2 given that $0 \leq x < 7/24$:

$$\text{Prob(consume News Bundle 2 } |x < 7/24) = \frac{2^{n_1}3^{n_2} - 2^{n_1+n_2} + 2^{n_2} - 1}{2^{n_1}3^{n_2}}. \tag{8}$$

A derivation of this expression is provided in the Supplemental Calculations.

Segment 2-8: Calculation of the expected demand for the other 7 segments (i.e., for $x \geq 7/24$) follows similar reasoning and is provided in the Supplemental Calculations.

3.2.1 Calculation of Expected Returns

Notice that in the simple model, we focus on the case where the numbers of news stories in the competing news bundles are identical ($n_1 = n_2 = n$). Obviously, when both firms exert low effort, their profit is $\pi_1 = \pi_2 = \gamma/2$. When both firms exert high effort, their profit is $\pi_1 = \pi_2 = \gamma/2 - k$.

In the asymmetric case, we assume that only Firm 2 makes a high investment in both the design and delivery of its news. In such a case, the demand of Firm 2 is computed by combining the expected demand from each of the eight segments:

$$\begin{cases} D_1 = \dfrac{11 - 2^{n+3} + 3^2 2^{2n} + 3^{n+1}(2^n - 1)}{2^{n+2}3^{n+1}}, & \pi_1 = \gamma D_1 \\ \\ D_2 = \dfrac{-11 + 2^{n+3} - 3^2 2^{2n} + 3^{n+1}(2^n 3 + 1)}{2^{n+2}3^{n+1}}, & \pi_2 = \gamma D_2 - k. \end{cases} \tag{9}$$

These expressions are the basis for Proposition 2 which describes the equilibrium outcome as a function of the number of signals in the news programmes (the competing programmes are assumed to contain the same number of stories).

Proposition 2. *In the simple case of one or two signals per news story and when the cost of news design (k) is sufficiently low, there exists a threshold of* $\underline{n} = f(k)$ *above which the unique equilibrium is that both firms exert high effort in designing their news (H, H).*

The expressions for both $\pi_i(H, L) - \pi_i(L, L)$ and $\pi_i(H, H) - \pi_i(L, H)$ monotonically increase in n (from the proof of Proposition 2). This implies that the effectiveness of news design as a strategy is strongly linked to the number of news stories in the programme. This obtains because a consumer's news choice depends on the expected distance between her ideal point and the closest story in the news programme. As explained earlier, better designed news programmes provide more signals for each story. Obviously, when there are more stories within a programme, the distance between w, the random draw for each news story, and the consumer's ideal point is smaller. However, consumer utility is not based on w, the true location of the news story; it is based on the estimated location of the news story which is a function of the signals that the consumer receives. In short, a consumer cannot recognize a tantalizingly close story unless she has received multiple signals about the story (which means that $\hat{w}$ is a more precise estimate of w). In sum, when the number of news stories is high, the benefit of better design is strong precisely because the likelihood of a tantalizingly close story is higher.

Admittedly, this is the result of a utility function where each consumer only looks for one favorite news story in the bundle. But as mentioned earlier, our objective is to understand the impact of consumers that look for their favorite stories. As long as consumers have a limited number of favorites, the result is robust (as noted earlier, a model where consumers have two favorite items is provided in the Appendix).

Ultimately, the benefit of having a better designed programme increases with the number of news stories. However, as summarized in Corollary 1, this relationship holds if and only if the number of stories in the news programme is above a threshold.

Corollary 1. *When n is small, better designed news can make the firm worse off even if the cost of design (k) is zero.*

Corollary 1 is the result of two countervailing effects of news design as highlighted in the monopoly case. Better news design increases m (the number of signals per news item), which means more estimated locations of news ($\hat{w}$). It is important to note that, *ex ante*, $\hat{w}$ is evenly distributed along the 0-1 continuum and is the basis for the viewing decision of consumers.

On the one hand, more locations for $\hat{w}$ reduces the potential distance between a consumer's preference point and the closest news item ($\min\{|x-\hat{w}|\}$).[16] This effect obtains because a consumer is more likely to benefit from a news story that is nearby when there are more potential locations for $\hat{w}$. For example, if a consumer is located at 1/8, the closest item from bundle one is 1/3. In contrast, the closest news item from bundle 2 is 1/4 and this consumer (located at 1/8) prefers 1/4 to 1/3.

On the other hand, more locations for $\hat{w}$ means that the distribution of news story locations is flatter. The more dispersed distribution of $\hat{w}$ can lead to a closest news item being more remote

[16] A higher number of signals item means that there are more potential "points" along the continuum for the expectations of $\hat{w}$. With a greater number of points spread along the continuum, there is a greater likelihood that a randomly selected consumer finds a news story nearby.

for a given consumer.

When the second effect is strong, the attractiveness of a news programme can be reduced by better design. The relative importance of these two countervailing effects is a function of the number of stories in the news programme. Returning to our example, News Bundle 2 may only have stories at 3/4, which is more remote than 2/3, the most remote outcome from News Bundle 1. When there are a limited number of news stories in the programme, the probability of this situation is significant. Thus, a consumer may prefer the news bundle for which the news provider implements low effort in its design and packaging.

3.3 The General Model

In this section, we generalize the simple case to a more complex news structure where multiple signals per news story are provided to viewers. We then examine the equilibrium news provision strategies, where news providers simultaneously choose both the "design effort" ($e_i \in \{L, H\}$) and number of news stories (n_i) to be included in their programmes.[17] We start from consumers' expected news locations.

Consumers' understanding of the stories depends on estimates which are based on signals observed in the news reports ($\hat{w}_{ij}$). This estimate depends on 1) the number of signals transmitted to consumers and 2) the actual realization of the signals. If consumers receive m_i signals in each news story, and there are y signals of '1' in the news, then the inferred location is given by $\dfrac{y+1}{m_i+2}$ (Welch 1992).[18] In other words, if a news story with m_i signals has a realization of $y = \sum_{t=1}^{m_i} s_{ijt}$, then the consumers' understanding of the event is:

$$\hat{w}_{ij} = \frac{1 + \sum\limits_{t=1}^{m_i} s_{ijt}}{m_i + 2}.$$

Note that $\hat{w}_{ij}$ is the consumer's understanding of the event *after consuming the news*. It is noteworthy that this estimate is not a straightforward counting of the signals, i.e., $\hat{w}_{ij} \neq \frac{\sum_{t=1}^{m_i} s_{ijt}}{m_i}$. As in the simple case, this estimate reflects a sharp but important assumption in our model: consumers process limited information from the news and reach an imperfect estimate of the location of the

[17]Note that we abstract away from the impact that the better design may have on the enjoyment derived from watching the news programme: we focus on the effect that better design has on the processing of information.

[18]We provide a concise proof in the Appendix.

story. Given this limitation, a consumer first accounts for her prior belief about the location of each news story $w \sim U[0,1]$, and then forms a posterior distribution about the expected location w of the news story as a function of the number of signals in the story according to Bayes' Rule, i.e, $\hat{w}_{ij} = E(w|y = \sum_{t=1}^{m_i} s_{ijt})$. When choosing between news programmes, a consumer does not know the realizations of the m_i signals and relies on the *ex ante* probability distribution of the signals. If a news story provides m_i signals, then a consumer knows that there are $m_i + 1$ possible realization of the signals. From DeGroot (1970), we know that the *ex ante* probability of observing y signals of '1' among the m_i signals in a news item w_{ij} is $\dfrac{1}{m_i + 1}$ (this is independent of y). In other words, each sequence of signals is of equal probability.

When a news programme is designed to provide more information to consumers, more signals in each news story are transmitted and consumers are better informed about each story covered in the news report. In contrast to the simple model of Section 3.1 where better designed news programmes deliver $2m_i$ signals, for the general model we assume that a consumer receives and processes $2m_i + 2$ signals in each piece of news. The additional extra 2 signals eliminate a problem created due to the endpoints of the linear city (the assumption brings computational convenience without loss of generality or robustness as long as the number of signals not small).[19] When consumers receive more information per story, two things change: 1) consumers' understanding of the story after consuming the news is better, i.e., the estimate of $\hat{w}$ is much closer the actual w and, 2) there are more signals (thus more possible realizations of the signal); this leads to a higher number of estimates and the *ex ante* probability distribution of the estimates becomes flatter. From a consumer's point of view, this means more consumers are likely to find a news story close to their preference point.[20]

3.3.1 News design with many signals

When neither firm exerts effort in news design, consumers receive $m_1 = m_2 = m$ signals per story from both programmes. The firms' demand depends solely on the number of news stories (n_i where

[19]Interestingly, with a spatial model in which consumers are uniformly distributed around a circular city (Tirole 1988), the results with $2m_i$ signals are identical to the linear city results with $2m_i + 2$ signals.

[20]In the extreme case of $m \to \infty$, the *ex ante* probability distribution of the estimates becomes a solid line between 0 and 1, and every consumer finds her ideal news.

$i = 1, 2$) in the programme. This implies that Firm 1's demand is given by:

$$D_1(\mathrm{L}, \mathrm{L}) = \frac{1}{2}\big(1 + \sum_{i=1}^{m}\big[(\frac{i+1}{m+1})^{n_1}(\frac{i}{m+1})^{n_2} - (\frac{i+1}{m+1})^{n_2}(\frac{i}{m+1})^{n_1}\big]. \tag{10}$$

Let us assume that one of the competitors (Firm 1) makes low investment in the design and delivery of its news programme while the competitor (Firm 2) makes a significant investment. In this case, the expected demand for Firm 1 is:

$$\begin{aligned} D_1(\mathrm{L}, \mathrm{H}) =& \frac{1}{(4m+8)(m+1)^{n_1}(2m+3)^{n_2}} \cdot \\ & \Big[(m+1)^{n_1+1}(2m+3)^{n_2} + \sum_{i=1}^{m+1}[(2m-i+4)i^{n_1}(2i-1)^{n_2} + (2m+4)i^{n_1}(2i)^{n_2}] \\ & - \sum_{i=1}^{m}[(2m-2i+3)i^{n_1}(2i+1)^{n_2} + (2m+4)i^{n_1}(2i+2)^{n_2} + (i+1)i^{n_1}(2i+3)^{n_2}]\Big]. \end{aligned} \tag{11}$$

Lemma 1. *Independent of the design effort, a news provider's demand increases with the number of news stories (n_i) in its programme.*

The intuition for Lemma 1 is that a news provider unequivocally increases the likelihood of a news consumer finding a preferred news story by increasing the number of stories. In other words, Lemma 1 implies that *ceteris paribus*, a news provider realizes a benefit by increasing the number of stories in the news programme. In fact, if "design and delivery" strategies are not available, a news provider can increase demand (at the expense of the competitor) by producing programmes that contain more stories. However, when "design and delivery" strategies are available, the relative attractiveness of increasing the number of news stories is affected.

Proposition 3. *When $n_i > \overline{n}$ and only Firm i designs its news, Firm i's demand exceeds that of Firm j (which does not design its news) independent of the number of news items in the programme ($D_i > 1/2 > D_j$).*

Proposition 3 shows that the design and delivery of news programmes can be a powerful competitive instrument. Not only can it be used to gain competitive advantage when the number of stories in the programme is sufficient, it can also be used to neutralize a competitor's strategy of increasing the number of news stories within a programme.

People in the news industry generally say that "*More News is Good News*". This idea seems to be reinforced by Lemma 1 given the belief that consumers watch news programmes to obtain information on stories that are of interest to them. Basically, if consumers want news then providing more should attract more viewers. However, when consumers are looking for their favorite stories, richer "easier to process" information may be a better idea.

Our analysis shows that by providing better designed programmes, news providers can affect the viewership or demand created for their programmes. In fact, Proposition 3 identifies conditions where investments in superior "design and delivery" dominate increasing the number of news items as a strategy. The proposition shows that when the number of news items exceeds a threshold, superior "design and delivery" cannot be nullified by a competitor who only competes by increasing the number of news items.

However, there are contexts where investment in "design and delivery" is not advantageous. The flipside of "design and delivery" as a competitive strategy is summarized in Proposition 4.

Proposition 4. *Even at zero cost, superior news design and delivery may reduce news provider's demand when the number of stories is sufficiently low.*

The intuition for Proposition 4 is that superior "design and delivery" leads to more diverse estimates for the expected location of news stories in the programme. As with the simple case, this has two effects on the expected demand for a news provider. First, more diverse estimates for the location of news stories mean that there is a greater *ex ante* likelihood of a better match to consumer preferences. Second, because the expected locations are more diffused, there is also a greater likelihood that any specific news story (in the programme) is further removed from the consumer's ideal story. The first effect is beneficial to a news provider since consumers are more likely to find a favorite. Conversely, the second effect is detrimental.

Essentially, news design increases the number of signals transmitted to consumers in each piece of news. To provide a concrete example of how more signals may "hurt", consider the following example with 2 competing news programmes where each programme contains but 1 news item. We assume that the *only* difference between the firms is that news from Firm 2 contains an informative Bernoulli signal (the probabilities of which are governed by the mechanism described earlier) and Firm 1 provides an uninformative signal.

In the absence of an informative signal from Firm 1, the estimated news location from Firm 1 is 1/2. Conversely, after receiving the signal from Firm 2, the estimated location of the news story from Firm 2 will be either 1/3 or 2/3. For consumers with preferences of $x < 5/12$, 1/3 is the preferred news. However, there is only 50% chance that they will receive this message from Firm 2. The is also a 50% chance, they will receive a message of 2/3 from Firm 2.

If they choose Firm 1, the expected location for the news story is always 1/2. Therefore, viewers with preferences $x < 5/12$ will choose Firm 2 half the time and the rest of the time they choose Firm 1. The same reasoning applies to the consumers with preferences $x > 7/12$. For the consumers with $x \in [5/12, 7/12]$, they always prefer Firm 1. Consequently, Firm 1 has a loyal segment from $5/12 \leq x \leq 7/12$, and has half of the demand from the rest of the market. In this simplified example, we see that the lack of precision in Firm 1's news gives it an advantage. This illustrates the idea that when the number of news stories offered in competing news programmes is small, more signals per story can decrease the probability that a consumer finds a preferred story in the news programme. When the number of stories is low, the wider spread of potential locations for $\hat{w}$ means there is a significant possibility that the nearest $\hat{w}$ for many consumers is remote. This can lead to superior "design and delivery" reducing demand for a firm's news programme.

In contrast, when the number of news stories in the programme is high, better design has the opposite effect. To be specific, when the number of stories is high, better design (meaning more signals per story) means that the likelihood of a precise fit is higher. This obtains because there are more potential locations for $\hat{w}$ and when the number of stories in the programme is high, there is likely to be at least one news story that is close to a consumer's ideal point.

3.3.2 Competitive News Structure

In the previous sections, we propose a model that elucidates how the design and delivery of news programmes affects consumers' enjoyment of consuming news. This provides a basis to consider a more general question: what strategy is likely to increase viewership for news programmes in a competitive setting? News providers can focus on maximizing the number of items contained in a news programme (which implies more journalists and camera team costs) or they can focus effort on the "design and delivery" of news programming (which implies higher costs in terms of production and design).

From the previous section, we know that investment in "design and delivery" leads to additional demand for a news provider when the number of news stories exceeds a threshold. That is, when the number of news stories in a news programme is low, a news provider does not realize a gain from superior "design and delivery".

These observations imply that there is synergy between the "design and delivery" of news and the number of news stories contained in a news programme. It follows that the simultaneous application of both strategies should be attractive because it allows the news provider to profit from the synergy. However, here we wish to examine the trade off between these strategies in a competitive setting.

For this purpose, we assume that a firm can either spend k to improve the "design and delivery" of its news programmes or it can invest k in news collection (i.e. to provide $2N$ pieces of news in its bundle). For example, if a firm is considering to lengthen its program from 20 to 25 minutes, the firm needs to decide whether to report more news items (to fill the extra 5 minutes) or to provide better design and more depth per news item while keeping the number of news items constant. In this respect, the cost of the alternative strategies is similar in the sense that they both take 5 minutes out of other programs or commercial time (the opportunity cost of the two strategies can be regarded as identical).

If a firm invests k in design, then it is restricted to providing N pieces of news in the programme, resulting a strategy set of (H, N), where the first item is the design effort and the second is the number of news items provided. If the firm invests k in news collection, its strategy set becomes (L, 2N). We focus on the case where the cost k is sufficiently low such that firms are willing to invest in these strategies and assume that firms choose between "design and delivery" and news collection efforts simultaneously. The idea is to represent the strategic decision of a news provider a) to hire more journalists and camera teams and place them globally or, b) to hire more production staff and invest more in attractive graphics and formatting.

Proposition 5. *There exists a $\underline{k}$ such that when $k < \underline{k}$, the unique pure strategy equilibrium in news provision is:*

$$\begin{cases} \textit{Both firms choose } \ (H, N) & \textit{if } N > \overline{N}, \\ \textit{Both firms choose } \ (L, 2N) & \textit{if } N \leq \underline{N}. \end{cases} \tag{12}$$

Notice that when both firms choose the same strategy, they divide the market evenly and each earns a profit of $\gamma/2 - k$. The equilibrium news provision shows that competing news providers will always choose the same news provision strategy, which actually leads to less profit than a situation where neither firm makes an investment in superior design/delivery or increased news collection.

This appears to be a standard "Prisoners' Dilemma"; however, it is actually a "Prisoners' Dilemma" with a difference. Independent of the situation, firms are worse off by having the options of either increasing the number of news items or improving the design and delivery of the news programme. It is surprising that news providers choose not to differentiate through the implementation of asymmetric strategies. However, the symmetry of the equilibrium may be an artifact of the model which assumes full market coverage i.e., with the same strategy, each firm obtains half of the market and spends k.

To see why this might be the case, consider a market outcome where one firm invests and the other does not. If the investing firm (say Firm 1) obtains demand greater than $\frac{1}{2}$ and the increase in demand leads to a profit increase that exceeds k, it follows that an equivalent gain in demand would be realized by Firm 2 who responds by implementing the same strategy. By implication, such a response would also lead to a profit increase that exceeds k. Consequently, the best response to an investment k by the competitor cannot be to spend 0.

Alternatively, consider a market outcome where one firm invests in news collection and the other invests in "design and delivery". One of the firms (say Firm 1) will have a profit that exceeds $\frac{1}{2}$. As before the competitor (Firm 2) would have been better off had it invested k towards the same strategy that Firm 1 chose.

As a result, as long as k is not too high, the unique outcome in this game is for both firms to implement the same "news programme" strategy.

The equilibrium also reveals the intrinsic interaction between news design and the structure of news programmes. The unique equilibrium of both firms adopting a high effort in design emerges only when there are sufficient stories in the programme ($N > \overline{N}$). Notice also that this threshold is a function of m, i.e., the number of signals within each news story. In fact when $N > 2.5m$, better news design is the dominant strategy.[21] Said differently, a superior "design and delivery" is most influential when the news programme contains many brief news items (N is large and m is small). This may explain why global news providers like CNN and Fox which gravitate towards a format that includes many brief news items also make substantial investments in the design and packaging

[21]Proof provided in the Supplemental Calculations.

of their news programmes.

4 Discussion

4.1 Limitations

A key assumption of the model is that consumers derive utility from a limited number of stories in any news programme. We adopt this setup to study the impact of consumer favorites on programme choice (by news consumers) and by implication, the equilibrium news design and delivery decisions of news providers. With this as the context, conventional wisdom would suggest that more news stories and better design should increase the appeal of a news programme. Our results indicate that while the former observation holds, the latter may not. That is, better designed and packaged news hurts the viewership of a news programme in some conditions.

We have modeled the news product as a series of conditionally independent Bernoulli signals. While conditional independence simplifies our analysis and highlights the idea that different bits of information in a report reflect different aspects of an event, this setup may be restrictive. In some cases, the signals contained in a news programme are not conditionally independent. When the information in a news report is correlated, then consumers need more information to reach the same level of understanding. In this case, the design of news programme becomes even more important and we suspect the qualitative insight provided by our model would remain.

Another limitation relates to the assumption that news providers' profits are a linear function of demand. In other words, we assume audience size is the sole focus of the news providers. This assumption is based on the observation that income for many media properties is primarily a function of audience size: there is typically a cost per thousand that advertisers pay and this determines how much an advertising slot is worth. The linearity of this relationship may not hold however, when advertising levels (of a media property) are high because advertisers strive to reach specific segments with their messages. Moreover, the news market is a two sided market with consumers and advertisers on each side. Thus, our model does not consider potentially interesting interactions between the "design of news" and the advertiser market. Endogenizing the value of advertising may be an interesting avenue of exploration in the context of news programme design. For example, a better designed news programme could attract more attention from consumers and this might increase the effectiveness of advertising. This interaction may be a basis to extend this research.

A final limitation of the analysis comes from the assumption that the sole effect of better designed news programmes is to transmit more signals to consumers. The idea that better design facilitates better transmission of information is certainly supported by research in consumer behavior. Nevertheless, the effect of news design may be multifaceted. Pleasing background music and module editing can also enhance the overall consumption experience and thus may directly influence the utility consumers obtain by watching a programme.

4.2 Conclusion

News providers invest millions of dollars to design and produce news programmes to attract viewers. These design efforts generally include the development of unique editing and writing styles, module design, pleasing graphics and music. Industry practitioners believe that a better designed news program is similar to any other better designed product: better design improves the quality of the news programme. We challenge this view by highlighting both the costs and benefits of increasing the quantity of information transmitted within a news story. A key assumption is that consumers process signals in the news. A better designed news program transmits more information to consumers by increasing the consumer's attention level or by presenting the information in way that makes it easier to understand. In a nutshell, the principal effect of superior design is to increase the number of signals that a consumer receives.

While a better designed news programme increases the quantity of information a consumer receives from each story within the programme, it does not necessarily benefit the news provider. Our model shows that a more refined design might hurt a news provider when there are a limited number of news stories in the programme. On the other hand, news design can be a powerful competitive instrument: once news programmes are complex. When news programmes contain a significant number of stories, the benefit of superior design cannot be nullified by a competitor that focuses on providing more stories.

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Appendix

Proof of expected locations

$\hat{w}_j = E(w_j|s_j)$. Therefore, we have:

$$E(w_j|s_j = 0) = \int_0^1 z \, d\,\mathrm{P}(w_j \le z|s_j = 0). \tag{A-1}$$

$$\mathrm{P}(w_j \le z|s_j = 0) = \frac{\mathrm{P}(w_j \le z, s_j = 0)}{\mathrm{P}(s_j = 0)} = \frac{\int_0^1 \mathrm{P}(w_j \le z, s_j = 0|w_j = \mu)d\mu}{\int_0^1 \mathrm{P}(s_j = 0|w_j = \mu)d\mu}.$$

Notice that $\mathrm{P}(s_j = 1)$=w_j is equivalent to $\mathrm{P}(s_j = 1|w_j = \mu)$=$\mu$. We know that, if $\mu \le z$, then $\mathrm{P}(w_j \le z|w_j = \mu) = 1$; and if $\mu > z$, then $\mathrm{P}(w_j \le z|w_j = \mu) = 0$, independent of s_j. Therefore, we have:

$$\mathrm{P}(w_j \le z, s_j = 0|w_j = \mu) = \begin{cases} (1-\mu) & \text{if } \mu \le z, \\ 0 & \text{if } \mu > z. \end{cases}$$

This gives us:

$$\mathrm{P}(w_j \le z|s_j = 0) = \frac{\int_0^z (1-\mu)d\mu}{\int_0^1 (1-\mu)d\mu} = \frac{z - \frac{1}{2}z^2}{\frac{1}{2}} = 2z - z^2. \tag{A-2}$$

Substituting $\mathrm{P}(w_j \le x|s_j = 0)$ with $2z - z^2$ in Equation A-1, we have: $E(w_j|s_j = 0) = 1/3$. Similarly, for two signals s_{j1} and s_{j2}, we have:

$$E(w_j|s_{j1} = s_{j2} = 0) = \int_0^1 z \, d\,\mathrm{P}(w_j \le x|s_{j1} = s_{j2} = 0). \tag{A-3}$$

$$\begin{aligned} \mathrm{P}(w_j \le z|s_{j1} = s_{j2} = 0) &= \frac{\mathrm{P}(w_j \le z, s_{j1} = s_{j2} = 0)}{\mathrm{P}(s_{j1} = s_{j2} = 0)} \\ &= \frac{\int_0^1 \mathrm{P}(w_j \le z, s_{j1} = s_{j2} = 0|w_j = \mu)d\mu}{\int_0^1 \mathrm{P}(s_{j1} = s_{j2} = 0|w_j = \mu)d\mu} = \frac{\int_0^z (1-\mu)^2 d\mu}{\int_0^1 (1-\mu)^2 d\mu} = 3(z - z^2 + \frac{z^3}{3}). \end{aligned} \tag{A-4}$$

Substituting $\mathrm{P}(w_j \le z|s_{j1} = s_{j2} = 0)$ with $3z - 3z^2 + z^3$ in Equation A-3, we have: $E(w_j|s_{j1} = s_{j2} = 0) = 1/4$.

Proof of Proposition 1:

Given that each w_j independently follows a uniform distribution, each realization of the signals in a news item has an equal probability. In other words,[a1]

$$\begin{cases} \mathrm{Prob}(s_j = 0) = \mathrm{Prob}(s_j = 1) & = 1/2, \\ \mathrm{Prob}(s_{j1} = s_{j2} = 0) = \mathrm{Prob}(s_{j1} = s_{j2} = 1) = \mathrm{Prob}(s_{j1} \ne s_{j2}) & = 1/3. \end{cases} \tag{A-5}$$

[a1] To see this, recall that s_{j1} and s_{j2} are not absolutely independent. They are independent conditional on w_j. Thus $P(s_{j1} = s_{j2} = 1) = \int_0^1 P(s_{j1} = s_{j2} = 1|w = z)f(w)dw = \int_0^1 P(s_{j1} = 1|w = z)P(s_{j2} = 1|w = z)f(w)dw = \int_0^1 P(s_{j1} = 1|w = z)P(s_{j2} = 1|w = z)dz = \int_0^1 z^2 dz = 1/3$.

Combining Equation (A-5) with (2) and (3), we have:

$$\begin{cases} \text{Prob}(\hat{w}_j = 1/3) = \text{Prob}(\hat{w}_j = 2/3) = 1/2, & \text{if } e = L, \\ \text{Prob}(\hat{w}_j = 1/4) = \text{Prob}(\hat{w}_j = 1/2) = \text{Prob}(\hat{w}_j = 3/4) = 1/3, & \text{if } e = H. \end{cases} \tag{A-6}$$

From Equation (4), we can calculate the firm's demand (denoted by D_L) when $e = L$. When $\frac{1}{3} < R < \frac{2}{3}$, we have:

$$\begin{cases} \text{if } x < \frac{2}{3} - R, & \text{Prob}(\min_{\forall w_i \in B}\{\mid x - E(w_i \mid m = 1) \mid\} < R) = \text{Prob}(\exists \hat{w} = 1/3) = 1 - (\frac{1}{2})^n, \\ \text{if } \frac{2}{3} - R < x < \frac{1}{2}, & \text{Prob}(\min_{\forall w_i \in B}\{\mid x - E(w_i \mid m = 1) \mid\} < R) = \text{Prob}(\exists \hat{w} = 1/3) + \text{Prob}(\exists \hat{w} = 2/3) = 1. \end{cases} \tag{A-7}$$

Therefore, $D_L(\frac{1}{3} < R < \frac{2}{3}) = 2((\frac{2}{3} - R)(1 - (\frac{1}{2})^n) + R - \frac{1}{6}) = 1 - (\frac{2}{3} - R)\frac{1}{2^{n-1}}$. By similar logic, we can calculate the firm's demand under different design strategies:

$$D_L = \begin{cases} 1 & \text{if } \frac{2}{3} \le R < \frac{3}{4}, \\ 1 - (\frac{2}{3} - R)\frac{1}{2^{n-1}} & \text{if } \frac{1}{3} < R < \frac{2}{3} \\ R + \frac{1}{6} - \frac{1}{2^n 3} & \text{if } \frac{1}{6} < R < \frac{1}{3}, \\ 4R(1 - \frac{1}{2^n}) & \text{if } R < \frac{1}{6}, \end{cases} ; \quad D_H = \begin{cases} 1 - (\frac{3}{4} - R)\frac{2}{3^n} & \text{if } \frac{1}{2} \le R < \frac{3}{4}, \\ 1 - \frac{1}{3^n 2} - (1 - 2R)(\frac{2}{3})^n & \text{if } \frac{1}{2} < R < \frac{1}{4} \\ 2R + \frac{1}{2}(1 - \frac{2^n+1}{3^n}) & \text{if } \frac{1}{8} < R < \frac{1}{4}, \\ 6R(1 - (\frac{2}{3})^n) & \text{if } R < \frac{1}{8}. \end{cases} \tag{A-8}$$

Because $\pi = \gamma D$, by comparing D_L and D_H, it is straightforward to derive the results of Proposition 1 and the threshold $f(k, R)$ for the combination of k and R under consideration.

Proof of Proposition 2:
Let us start from Firm i's payoff when its competitor (Firm j) incurs low effort in news promotion ($e_j = L$).

$$\begin{aligned} \pi_i(H, L) - \pi_i(L, L) &= \gamma D_i(H, L) - k - \gamma D_i(L, L) \\ &= \gamma(\frac{-11 + 2^{n+3} - 3^2 2^{2n} + 3^{n+1}(2^n + 1)}{2^{n+2}3^{n+1}}) - k. \end{aligned} \tag{A-9}$$

$$\begin{aligned} \frac{\partial(\pi_i(H, L) - \pi_i(L, L))}{\partial n} &= \gamma \frac{11 \ln 6 + 3^2 4^n(\ln 3 - \ln 2) - 3^{n+1} \ln 2 - 2^{n+3} \ln 3}{2^{n+2}3^{n+1}} \\ &= \gamma \frac{11 \ln 6 + 2^n \ln \frac{3^{6n-8}}{2^{6n}} + (4^n \ln 11 - 3^n \ln 8)}{2^{n+2}3^{n+1}}. \end{aligned} \tag{A-10}$$

When $n \ge 4$, $\frac{3^{6n-8}}{2^{6n}} > 1$. When $0 < n < 4$, it is straightforward to show that $11 \ln 6 + 2^n \ln \frac{3^{6n-8}}{2^{6n}} > 0$. Thus we have $\frac{\partial(\pi_i(H, L) - \pi_i(L, L))}{\partial n} > 0$.

Similarly, we can show that $\frac{\partial(\pi_i(H, H) - \pi_i(L, H))}{\partial n} > 0$ always. These two derivatives being positive suggests that the benefit of having H increases with n.

Therefore, exists a threshold of $\underline{n} = f(k)$ such that high effort in news promotion ($e_i = H$) is the dominant strategy if and only if $n > \underline{n}$. This implies that the unique pure strategy equilibrium is (H, H) when $n > \underline{n}$. $\square$

Proof of Corollary 1: It is straightforward to show that when $n = 1$, $\pi_i(H, L) = \frac{4\gamma}{9} - k$. This is strictly smaller than $\gamma/2$.$\square$

Proof of the independent and identical probability in the case of m signals:

Let $S = \sum_{t=1}^{m_i} s_{ijt}$, then the probability of observing y signals of '1' among the m_i signals can be written as:

$$\text{Prob}(S = y) = \int_0^1 P(S = y|w_{ij} = \mu)d\mu = \int_0^1 \binom{m_i}{y}\mu^y(1-\mu)^{m_i-y}d\mu = \frac{1}{m_i+1}. \tag{A-11}$$

Proof of the inferred location given y signals of 1 in the case of m signals:

This proof shares similar logic to the proof of the simple case at the beginning of the appendix.

$$E(w_{ij}|S = y) = \int_0^1 zdP(w_{ij} \leq z|S = y). \tag{A-12}$$

We also know $P(w_{ij} \leq z|S = y) = \dfrac{\int_0^z \binom{m_i}{y}\mu^y(1-\mu)^{m_i-y}d\mu}{\int_0^1 \binom{m_i}{y}\mu^y(1-\mu)^{m_i-y}d\mu}$. Thus we have:

$$E(w_{ij}|S = y) = \int_0^1 z(m_i+1)\binom{m_i}{y}z^y(1-z)^{m_i-y}dz = \frac{y+1}{m_i+2}.\square \tag{A-13}$$

Proof of Lemma 1: For one news story, each possible realization of its expected location $(\dfrac{y+1}{m_i+2})$ has an equal probability of $\dfrac{1}{m_i+1}$. Given that the n_i news stories are independent, it is obvious that

$$\forall\, y \in [0, m_i], \begin{cases} \text{Prob}(\exists\, \hat{w}_{ij} = \dfrac{y+1}{m_i+2}) = 1 - (\dfrac{m_i}{m_i+1})^{n_i}, \\ \text{Prob}(\forall\, \hat{w}_{ij} \neq \dfrac{y+1}{m_i+2}) = (\dfrac{m_i}{m_i+1})^{n_i}. \end{cases} \tag{A-14}$$

The first probability increases and the second story decreases with n_i. The above equations imply that for any potential realization of $\hat{w}_{ij}$, when the number of news stories (n_i) increases, the probability of finding such one increases and the probability of not finding any decreases. It follows directly that D_i increases when there more news stories in the preview. $\square$

Proof of Proposition 3:

From Lemma 1, D_j increases with n_j, thus we need to prove that $\lim\limits_{n_j \to \infty} D_j < \dfrac{1}{2}$.

Suppose only Firm 2 incurs high effort ($e_1 = L, e_2 = H$), rearranging Equation (11), we have

$$
\begin{aligned}
D_1(\mathrm{L},\,\mathrm{H}) = \frac{1}{(4m+8)}\Bigg[& m+1+(m+3)(\frac{2m+1}{2m+3})^{n_2}+(2m+4)(\frac{2m+2}{2m+3})^{n_2} \\
& + \sum_{i=1}^{m}\Big((2m-i+4)(\frac{i}{2m+3})^{n_1}(\frac{2i-1}{2m+3})^{n_2}+(2m+4)(\frac{i}{m+1})^{n_1}(\frac{2i}{2m+3})^{n_2}\Big) \\
& - \sum_{i=1}^{m}\Big((\frac{i}{m+1})^{n_1}\big((2m-2i+3)(\frac{2i+1}{2m+3})^{n_2}+(2m+4)(\frac{2i+2}{2m+3})^{n_2}+(i+1)(\frac{2i+3}{2m+3})^{n_2}\big)\Big)\Bigg].
\end{aligned}
\tag{A-15}
$$

Let $n_1 \to \infty$, notice that within the two summations, all fractions with the power of n_1 are less than 1. Therefore, we have

$$
\forall m > 0,\ \lim_{n_1\to\infty} D_1 = \frac{1}{4m+8}\left(m+1+(m+3)(\frac{2m+1}{2m+3})^{n_2}+(2m+4)(\frac{2m+2}{2m+3})^{n_2}\right). \tag{A-16}
$$

From (A-16), we have:

$$
\begin{aligned}
\lim_{n_1\to\infty} D_1 < \frac{1}{2} &\Longleftrightarrow m+3 > (m+3)(\frac{2m+1}{2m+3})^{n_2}+(2m+4)(\frac{2m+2}{2m+3})^{n_2} \\
&\Longleftrightarrow 1 > (\frac{2m+1}{2m+3})^{n_2}+2(\frac{2m+2}{2m+3})^{n_2} \\
&\Longleftrightarrow 1 > (1-\frac{2}{2m+3})^{n_2}+2(1-\frac{1}{2m+3})^{n_2}.
\end{aligned}
\tag{A-17}
$$

Notice that the right side of the inequality in (A-17) is decreasing in n_2, and its limit when $n_2 \longrightarrow \infty$ is zero. Therefore, we can find an $\overline{n_2}$ such that when $n_2 > \overline{n_2}$, $\lim_{n_1\to\infty} D_1 < \frac{1}{2}$. $\square$[a2]

Proof of Proposition 4: Let us focus on Firm 2. We need to prove that when n_2 is small, $D_2(\mathrm{L},\,\mathrm{H}) < D_2(\mathrm{L},\,\mathrm{L})$.

From Equation (10), we can show that $\lim_{n_2\to\infty} D_2(L,L) = \frac{1}{2}(1+(\frac{m}{m+1})^{n_1})$. From (11), we calculate $\lim_{n_2\to\infty} D_2(L,H) = \frac{1}{2}\left[1+\frac{m+3+(\frac{m}{m+1})^{n_1}(m+1)}{2m+4}\right]$. Thus, we have:

$$
\lim_{n_2\to\infty} D_2(L,H) - \lim_{n_2\to\infty} D_2(L,L) = \frac{m+3}{2m+4}\left[1-\left(\frac{m}{m+1}\right)^{n_1}\right] > 0.
$$

It is straightforward to check that when $n_1 = n_2 = 1$, $D_2(L,H) - D2(L,L) = \frac{-1}{12+8m} < 0$. Considering $D_2(L,H)$ and $D2(L,L)$ as functions of n_2, we know that $D_2(L,H)$ and $D_2(L,L)$ are increasing in n_2 and intersect. Therefore, there exists an $\underline{n_2}$ such that when $n_2 < \underline{n_2}$, $D_2(L,H) < D_2(L,L)$. This means news design hurts the firm if the number of news stories is small. $\square$

[a2] In the supplemental calculations, we show that $\overline{N}$ does not need to be very large and we provide a relevant threshold $\overline{n_i}$.

Proof of Proposition 5:

Denote by $D_1((e_1, e_2), (n_1, n_2))$ as Firm 1's demand at different design effort and news collection levels, we can describe Firm 1's payoff in the news provision game in Table 1.

		Firm 1	
	(L, N)	(H, N)	(L, 2N)
Firm 2 (L, N)	$\gamma/2$	$\gamma D_1((H,L),(N,N)) - k$	$\gamma D_1((L,L),(2N,N)) - k$
Firm 2 (H, N)	$\gamma D_1((L,H),(N,N))$	$\gamma/2 - k$	$\gamma D_1((L,H),(2N,N)) - k$
Firm 2 (L, 2N)	$\gamma D_1((L,L),(N,N))$	$\gamma D_1((H,L),(2N,N)) - k$	$\gamma/2 - k$

Table 1: Firm 1's payoff in the news provision game

From Lemma 1, we know that D_1 increases with n_1. Thus we find $\underline{k}$ such that when $k < \underline{k}$, $(L, 2N)$ dominates (L, N). Therefore, the equilibrium must be in the 4 cells at lower right part of Table 1. Because the market is fully covered, we have $D_1((L,H),(2N,N)) = 1 - D_1((H,L),(2N,N))$. This suggests:

$$\gamma D_1((H,L),(2N,N)) - k - (\gamma/2 - k) = (\gamma/2 - k) - (\gamma D_1((L,H),(2N,N)) - k).$$

Because the symmetry of the payoffs, the equilibrium is either $((H,H),(N,N))$ or $((L,L),(2N,2N))$.

We now show identify the conditions where the equilibrium is $((H,H),(N,N))$, i.e., both firms choose (H,N). If this is indeed the equilibrium, then $1/2 > D_1((H,L),(2N,N))$ is the sufficient and necessary condition. In the proof of Proposition 2, we found a threshold $\overline{n_2} = \max\{20, 2m\}$ such that when $n_2 > \overline{n_2}$, $D_1 < 1/2$. There, $\overline{n_2} = 20$ when $m \leq 11$ because n_1 can be any positive integer. In the news provision game, since $n_1 = 2N = 2n_2$, one can show that for $m \leq 11$, when $N \geq 2m$, $1/2 > D_1((H,L),(2N,N))$ holds. Therefore, we use $\overline{N} = 2m$ as the threshold for the game and when $N \geq \overline{N}$, the unique equilibrium is $((H,H),(N,N))$.

We now find the condition for the equilibrium $((L,L),(2N,2N))$, i.e., both firms choose $(L,2N)$. The sufficient and necessary condition for this equilibrium is $1/2 < D_1((H,L),(2N,N))$. In the Supplemental Calculations, we show that when $N \geq \underline{N} = m$, $1/2 < D_1((H,L),(2N,N))$ holds. □

The Case of Two Favorites:

When consumers have two favorite news stories, the utility function is as follows:

$$u_i = R - \min_{\forall w_{ij} \in B_i} \{| \, x - E(w_{ij} \mid m_i) \, |\} - \min_{\forall w_{ik} \in B_i} \{| \, x - E(w_{ik} \mid m_i) \, |\}, \text{ where } j \neq k. \tag{A-18}$$

The objective is to examine if the key finding (i.e. news design can adversely affect demand for a firm when the number of news stories in the bundle is small) extends to a situation where each consumer has more than one favourite. For this purpose, we examine a situation where two competing news programmes contain only 2 news stories.

Similar to the case examined earlier in the paper, a better designed news programme provides more information per news story. This is reflected in a flatter distribution for $\hat{w}$. We consider a parsimonious case, in which low investment in design by Firm 1 means that its signals are uninformative. In this case, the expected location of $\hat{w}$ is 1/2. Firm 1's competitor, Firm 2, invests in design and this means the signals in its news programme are informative such that $p(s_i = 1) = w_i$. Thus, the expected location of a news item after viewing Firm 2's news programme is either 1/3 or 2/3.[a3]

For news from Firm 1, we know that $\text{Prob}(\hat{w}_{1j} = 1/2) = 1$ and $u_1 = R - 2(\mid 1/2 - x \mid)$. For news from Firm 2, there are three possible outcomes: both news stories are at 1/3, both news stories are at 2/3, and one news story at 1/3 and the other at 2/3. The probability distribution for these three possible outcomes are $\frac{1}{4}, \frac{1}{4}$ and $\frac{1}{2}$ respectively. To simplify the argument, we focus on the expected demand (realized by Firm 2) in the segment $0 < x < 1/2$. By symmetry, the total demand for Firm 2 obtains by doubling the expected demand from the segment $[0, \frac{1}{2}]$. The utility for a consumer located at x by choosing Firm 2 for the three possible outcomes is as follows:

$$\begin{cases} \text{Prob}(\hat{w}_{21} = \hat{w}_{22} = 1/3) = 1/4, & u_2 = \begin{cases} R - 2(1/3 - x) & \text{if } 0 < x < 1/3, \\ R - 2(x - 1/3) & \text{if } 1/3 \leq x < 1/2, \end{cases} \\ \text{Prob}(\hat{w}_{21} = \hat{w}_{22} = 2/3) = 1/4, & u_2 = R - 2(2/3 - x) \\ \text{Prob}(\hat{w}_{21} \neq \hat{w}_{22}) = 1/2, & u_2 = \begin{cases} R - 1 - 2x & \text{if } 0 < x < 1/3, \\ R - 1/3 & \text{if } 1/3 \leq x < 1/2. \end{cases} \end{cases} \tag{A-19}$$

Notice that when $\hat{w}_{21} \neq \hat{w}_{22}$, for $0 < x < 1/3$, $u_2 = u_1$. In this case, the programmes of Firms 1 and 2 are perceived identical by consumers so we assume that the market is split equally between the two firms.

The expressions above imply the following level of demand for Firm 2 for consumers located between 0 and 1/3: $D_2(0 < x < 1/3) = \text{Prob}(u_2 > u_1) + \frac{1}{2}\text{Prob}(u_2 = u_1) = \text{Prob}(\hat{w}_{21} = \hat{w}_{22} = 1/3) + \frac{1}{2}\text{Prob}(\hat{w}_{21} \neq \hat{w}_{22}) = 1/2$. For $1/3 \leq x < 5/12$, $D_2(1/3 \leq x < 5/12) = \text{Prob}(\hat{w}_{21} = \hat{w}_{22} = 1/3) = 1/4$. For $5/12 \leq x < 1/2$, $u_2 < u_1$, thus $D_2(5/12 \leq x < 1/2) = 0$.

Extrapolating this to the entire market, it is straightforward to show that the overall demand for Firm 2 (which has invested in designing its news) is $D_2 = \frac{3}{8} < \frac{1}{2}$. This implies that news design results in reduced demand for Firm 2 when the number of news stories in the programme is two (i.e. a small number).

[a3]This setup is a polar case of the simple model presented in the main paper. It is useful to illustrate the consistency of the results for a model where each consumer has two favorites.