"Fake news alert!": A game of misinformation and news consumption behavior

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"Fake News Alert!": A Game of Misinformation and News Consumption Behavior[1]

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Abstract

This paper examines the impact of behavioral factors in propagation of fake news. Using Spence (1978) framework, we find that the perfect Bayesian Nash equilibrium is *pooling equilibrium,* i.e., *fake news* producers to mimic actions of *true news* producer, which is influenced by factors like ideology, awareness, informational utility and fear of missing out information of news- consumers. Interestingly, the chain of fake news can be broken iff degree of awareness is significantly high. A threshold level of awareness level is determined using simulation, beyond which pooling breaks despite of high influence of other factors, which throws light on possible policy interventions.

Keywords: Fake news, Asymmetric Information, Bayesian games, Signaling, Fact checking

JEL Codes: D82, D91, L20

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1. Introduction

'Fake news' gained prominence during the controversial 2016 US election, marked by the deliberate spread of misinformation across social networks to influence voters. The unraveling of the Cambridge Analytica scandal further intensified allegations of fake news meddling with the electoral outcome, as fake news producers used algorithms to create tailored 'content' for users, influencing their voting decisions (Heawood 2018; Hinds *et al.* 2020). Since 2016, the widespread dissemination of fake news has led to the emergence of influential literature exploring the potential impact of the spread of fake news through social networks, specifically during electoral processes such as the presidential elections of Germany (Zimmermann and Kohring 2020) and Italy (Cantarella *et al.* 2023), and the BREXIT referendum (Marshall 2018).

Few studies put forward the supply incentives that fake producers may have to deliberately distort news from the true state of the world, owing to the pecuniary benefits derived from advertisement revenue and subscriptions earned through generating viral content (Gentzkow, 2016; Allcott and Gentzkow 2017). However, most of the research concentrates on fake news dissemination through social networks, thus reinforcing the *supply-side* narrative of the fake news market (Rackaway 2014; Silverman et al. 2016; Gottfried and Shearer 2016; Makse and Bovet 2019). The literature on fake news mostly skews towards the supply side of the fake news market, and hence the demand side issues are underexplored. This paper explores the 'behavioral' issues that may drive the demand for fake news in the market.

Understanding the *demand framework* of fake news becomes imperative, given *supply* concerns are well addressed by the profit-maximizing objective of the fake news producers. All rational consumers would prefer to be informed about the *true* state of the world; however, consumers are unaware of the validity of the information received (*true* or *fake).* With information asymmetry, the consumer's choice to accept or reject information hinges on their behavioral factors, specifically their level of awareness and ideological sensitivity, as elucidated in the experimental study of Badrinathan (2021). In our paper, we elucidate how behavioral factors such as *informational utility, awareness level,*

ideological sensitivity, and fear of missing out influence the *consumption demand* for fake news. We have categorized a consumer based on their degree of awareness level and ideological sensitivity, and we use Spence's (1973) framework to substantiate how receivers interpret the validity of news based on these behavioral factors. From categorizing the population, we try to identify the cohort with awareness beyond a certain threshold, who will be able to detect fake news. Verifying information is costly since fact-checking websites are not necessarily apolitical and may have an incentive to suppress fact-checks (Kim and Koh 2020). However, even when verifiability is not a concern, consumers may reject to cross-verify some information when they have a higher preference for information given by informational utility (Freedman and Sears 1965) or a heightened fear of missing out on true information (Ahmed 2006). Therefore any form of intervention to increase awareness fails if consumers' decision to accept news is strongly determined by such behavioral factors (Gentzkow *et al.* 2015; Badrinathan 2021). While the likeliness of consumers with a higher informational utility to accept any news irrespective of its validity can be addressed through an intervention to increase awareness level in our model, the same could not be said for consumers with a heightened level of fear of missing out. From our results, we obtain that for such consumers, any form of intervention on increasing awareness level will be effective to restrict fake news for an optimal threshold level of awareness. Simulation results serve as the basis for a policy framework that establishes the range for the critical awareness threshold level that these facts–*checking websites* will strive to achieve for restricting the dissemination of fake news regardless of any changes in consumers' behavioral aspects.

Elaborating on the *supply* side, our model distinguishes between two types of news producers in the market: *true* news producers and *fake* news producers. The presence of information asymmetry occurs at the consumers' end, as they are unaware of whether the news they receive originates from true news producers or fake news producers. Given the ideological beliefs of the population, both types of news producers can generate a *'favorable'* or *'unfavorable' news (or signals)* to the ideology of a representative consumer. Regardless of the nature, all news producers would maximize profits. Even when a true news producer would typically be inclined to share truthful information, however, their decision to send a *'favorable and true'* news or an *'unfavorable and true'* news depends on which strategy maximizes their payoff, taking into account the revenue generation structure of the producers. The standard assumption of profit-maximizing behavior of news producers in our model is not far-fetched from the real world. Saez-Trumper et al. (2013) show that there is prevalence

of selective preference or allocation of airtime to certain issues over others is commonly referred to as 'coverage bias'.

This coverage bias is driven by the demand bias of the consumers where they may exhibit a preference for confirmatory news. Allcott and Gentzkow (2017) elucidated the role of 'psychological utility' received from consuming information closer to their ideological and psychological bias, known as the confirmation bias (Frey 1986; Stroud 2008, Easley and Kleinberg 2010; Spohr 2017). Fake news producers try to exploit the demand side bias, such as the confirmation bias, of consumers to create a tendency in them to interact with news pieces that align with their ideology, known as selective exposure. The demand side bias of the consumer depends on behavioural aspects considered in our analysis such as informational utility, awareness level, ideological sensitivity and fear of missing out. Hence, we have presented the perspective of consumers based on such behavioural aspects and explored their potential strategies for *accepting* or *rejecting* information.

This study provides a theoretical prediction on how the propagation of fake news can be stalled, using Spence's (1978) model. Since, delivering *true* news entails extensive research efforts, which can be conveniently skipped while producing fake news, mimicking true signals can be costly for fake news producers. We derive fake news sustains in the system whenever the pooling equilibrium holds indicating the inability of consumers to segregate between true and fake news. We obtain that pooling equilibrium holds across all categorizations, and the possibility of a separating equilibrium holds for only one category i.e. informed consumers with strong ideology. However, in this equilibrium the optimal strategy of the consumer is to reject irrespective of the source of the signal, making it a babbling equilibrium. From a policy standpoint, one may recommend a rise in awareness level as the likelihood of a break in pooling equilibrium in the model increases with an increased awareness level. However, it is intriguing that despite an increased awareness level, the pooling equilibrium might persist if there is a growing fear of missing out on favorable news among consumers. This suggests that behavioral factors can play a role in maintaining the pooling equilibrium, even in the presence of heightened awareness. Through simulation we obtain a critical awareness threshold level of awareness beyond which the condition for the break in pooling equilibrium remains unaffected by the impact of any behavioral factors. Hence policies must be dedicated to attaining the optimal threshold awareness level.

The remainder of the paper is organized as follows. The following section discusses the literature and contribution of the paper to the existing literature, section 3 introduces the Bayesian game model and discusses the results derived; conclusions are drawn in section 4.

2. Literature Review

The literature on fake news developed immensely post the controversial 2016 US presidential elections. This is unsurprising considering the potential impact of misinformation on presidential election generated significant interest among researchers, leading them to investigate and understand the concept of fake news. Though the general mold of fake news is in the form of news articles with no factual basis, identifying fake news can be a difficult task in itself. This is because fake news can take on different forms, such as news fabrication, photo manipulation, data manipulation, and clickbait videos (Kalsnes 2018; Tandoc *et al.* 2017).

The emergence of literature on fake news is intriguing. While a considerable portion of previous literature is dedicated towards the proliferation of misinformation across social networks, recent studies delve into the dynamics of such misinformation transfer across social networks from the perspective of network economics. Another significant portion of the literature explores the consequences and challenges posed by such proliferation to the functioning of democratic structures and policies. Therefore we explain the literature on fake news and misinformation in three segments i.e. (i) fake news and the role of social media in its propagation, (ii) literature on the proliferation of rumors across social networks from the purview of network economics, (iii) consequences of fake news and misinformation.

Social media, along with the increased reliance on online news, has played a significant role in the spread of misinformation (Gottfried and Shearer 2016).[2] There is an abundance of literature that holds social media platforms, particularly Facebook, accountable for the propagation of fake news during the 2016 US election (Silverman *et al.* 2016).[3] One of the groundbreaking papers in this regard was by Allcott and Gentzkow (2017).[4] Guess et al.

[2] Recent shreds of evidence show that 62% of US nationals depend on online consumption as a source of their information (Gottfried and Shearer, 2016).
[3] The most popular fake news were widely shared on Facebook (Silverman *et al.* 2016).
[4] Their study was based on web-browsing data of 1200 persons in a post-election online survey and a database of 156 election-related news stories that were categorized as false. The articles that were classified as fake in their study were shared on Facebook about 0.386 million times.

(2018) conducted a similar study and discovered that Facebook was one of the three previously visited sites by respondents before encountering a fake news article.[5] While it can be established from these kinds of literature that there does exist a strong causality between social media and fake news, but this is certainly not an end in itself.

To understand the dissemination of fake news in a network framework, one must consider the broader context of consumers' behavioral patterns that contribute to the acceptance of fake news. This has not been extensively addressed in the literature on fake news. Among the existing studies, Gentzkow et al. (2016) have comprehensively explored market determinants of biases. They have put forward the role of psychological utility as a 'demand-side' bias that gives consumers an incentive to prefer confirmatory news irrespective of its authenticity. The psychological utility obtained from consuming confirmatory news is itself a result of behavioral bias, known as confirmation bias. Such demand-side biases of consumers are determined by factors like ideological sensitivity and awareness level (Oosterhoff et al., 2018; Badrinathan, 2021). In our paper, based on the degree of such determinants, we categorize the population and obtain the probable propagation of fake news for each such category. Evidence from the literature indicates that consumers receive such confirmatory signals from their peers through social networks. Consumers tend to seek out peers who share the same preferences as themselves, a phenomenon known as homophily. As a result, they frequently base their decisions to accept or reject signals on the choices made by such peers within the networks. These behavioral patterns, where an individual in a network tends to follow others regardless of their private information, make an individual ‘node’ in a network susceptible to misinformation (Frey, 1986; Nickerson, 1998; Stroud, 2008; Spohr, 2017). The individuals in such cases get direct benefit by aligning their consumption pattern with other 'nodes' in the network, known as the informational effect (Easley and Kleinberg, 2010). These have been previously explained by the concept of 'information cascade' and 'herding behavior' in Banerjee (1992).

Fake news producers hinder the ability of the information receivers to communicate their private information effectively (Bloch et al. 2020, Levit 2020). As can be understood from Bloch et al. (2020), the presence of biased agents often hinders the possibility of unbiased

[5] They combined responses to an online survey from a national sample survey of more than 2500 individuals with web-traffic data collected from their computers for the period October 7-November 14, 2016. More direct inference about the role of Facebook was observed by examining the URLs visited by a respondent immediately prior to visiting a fake news website

agents to communicate the *true* state. The perverse effect of this intervention, in the real world, on communication might come in the form of a rise in prejudices, stereotypes, and other adverse social welfare effects. Common citizens depend on news sources or political representatives for the interpretation of news on international trade and domestic policies. Hence, there are increasing chances that their views can get influenced by misinformation based on symbolic values like religion, cultural aspects, and ideological preferences (Jenny 2019). The rise of populism saw a number of countries showing weaker preference for trade liberalization and market competition. The recent rise in protectionist sentiments across the US and India could be explained by the surge of such symbolic values to a certain extent (Flynn et al. 2022). The consequence of fake news has been explained in the literature in areas of electoral and democratic processes (Banks 1990; Callander and Wilkie 2007), international trade (Rho and Tomz 2017), market leadership (Alvim and Pires 2017; Domenico et al. 2020), and vaccines (Shi 2013).

Considering the evil consequences of fake news, upcoming researches in the field are aimed at finding method and policies for decelerating fake news. Fact checking websites are one such tool for creating awareness towards fake news (Badrinathan and Chauchard 2022). While fact checking websites has been socially beneficial to a large extent, however there are substantial problems with scalability and trust therefore falls short of realizing its potential (Allen *et al.*2021). Consumers cannot fact-check every piece of information that comes their way, leading to a situation where fact-checking is typically conducted when the potential cost of accepting false information outweighs the cost of verifying the news source (Egorov and Carroll 2019; Bervoets and Venkatesh 2022). Similar to the framework proposed by Kim and Koh (2020), the presence of political inclinations among fact checkers creates an incentive to present favorable evidence while suppressing unfavorable ones. This behavior can exacerbate biases instead of reducing them, as highlighted by Cheah (2016).

3. Model

We build upon a model of dynamic games with incomplete information involving two rational economic agents- the news producer (sender) and the consumer (receiver), similar to Spence's (1978) framework. We assume that there is a representative consumer with some ideological belief ($\tilde{\imath} \in \mathbb{R}$) spread over uniform distribution $[\underline{i}, \bar{i}]$ and the knowledge level ($\beta \geq 0$) uniformly distributed over $[a, b]$. The distribution of ideological beliefs and the

knowledge level of the population is common knowledge. There are M numbers of producers and N consumers in the economy, such that $M < N$.

There are two types of news producers, λ proportion of *True* news producers and $(1-\lambda)$ proportion of *Fake* news producers in the economy. There is information asymmetry in our model from the consumer's side and they can only observe the news but is unaware of the source of the news. Given the ideological belief of N consumers, a representative news producer can either produce news (*signal* their *type*) aligned to the ideology of the representative consumer, which is designated as *favourable* news(F) or otherwise, as *unfavourable*(UF) news. Therefore, the action profile of the producer is thus given as $\{F, UF\}$. *True* news producer is ideally of the behavioral type who sends *signals* accurate to the true state of the world irrespective of whether it is *favorable* or *unfavorable* to the ideological standpoint of consumer. Therefore, either *news* which is '*favorable and true'* or '*unfavorable and true'* will be produced by the true type. However their optimal *strategy* is contingent upon their profit maximizing behavior. *Fake* news producers are profit maximizers as well, but news from them is away from the *true state* irrespective of whether favourable or unfavourable. The news producers earn revenue from the subscriptions by the consumers which is dependent on higher reach (g) among the consumers. Now, if the content of the news is more aligned with the given ideological belief of the consumers, it is more likely that the circulation of the news will be higher (Gentzkow and Shapiro,2013)[6].

Mathematically we can write, $g = g(||i - \tilde{\imath}||)$, where $\left|\left|i - \tilde{\imath}\right|\right|$ is the distance function defined over the information i from the preferred ideological position $\tilde{\imath}$ of the consumer. Also,$g' < 0$, indicating that greater the distance of the information from consumer's preferred ideological position, lower will be the reach among consumers. This gives producers an incentive to generate content aligned with the ideological preferences of their consumers, making the profit of the producer (π), a function of greater reach (g). We therefore express the profit function as: $\pi = \pi\big(g(||i - \tilde{\imath}||)\big), g' < 0, \pi' > 0$

As higher reach garners higher revenue for the producers, therefore we simplify and assume that the payoff from generating favorable ideological content is π_1 which is greater than the payoff from producing unfavorable *news* (π_2), i.e., $\pi_1 > \pi_2$. *Fake* news producers always face a risk of getting exposed/caught with probability 's, therefore fake types would calculate

[6] Consumers tend to choose news outlet whose reporting slanted towards their political ideology (Gentzkow and Shapiro 2013)

their expected payoff as $E(\pi) = s(\pi) + (1-s)0$. So when a *fake* news producer goes undetected they get the usual payoff of π_j , $\forall j = 1,2$ like any *true* news producer and receive nothing when they get exposed[7]. All news producers face expenses on conducting research and publishing content. However, realistically the research costs associated with production of accurate signals reflecting the *true state* of world should be higher.[8] Consequently, if receivers *reject* the producer's content, *true* news producer suffers greater losses compared to *fake* news producers, as the former incur higher research costs. Therefore, in our model, the cost for true news producers (C_1) is greater than the cost (C_2) for producers of fake news. Given the information asymmetry in the model, the consumer has a prior belief in the *types* of producers which is contingent on the proportion of news producers in the economy. Specifically, we assume that her prior belief to be set at λ for *true* news producer and $1-\lambda$ for *fake* news producers. As it occurs in the literature of Spence's *signaling* model, there is a Bayesian updation which form the *posterior* belief of the consumer. Followed by the updation, consumer has a *posterior* belief of p that *favorable signal* (F) is coming from *true* news producer and $(1-p)$ probability that it is from *fake* news producer. Similarly, the consumer attaches probability q and $(1-q)$ to *unfavorable signal* (UF) coming from *true* and *fake* news producer respectively. The consumer can either *accept* (A) signal or reject (R) the *signal* and hence the strategy profile can be given as $\{A, R\}$.

Consumers value information in general and from any kind of information i it receives an information utility given by $U(i)$. As discussed previously in the literature, consumers have a preference for confirmatory news and hence, receive disutility from consuming news piece that goes against their ideological standpoint, given by $\alpha||i-\tilde{\imath}||$, where $||i-\tilde{\imath}||$ gives the distance of the information received by the consumer from her preferred ideological position $\tilde{\imath}$. The magnitude of this disutility depends on the degree of ideological sensitivity given by α. Therefore, disutility would be higher for a consumer who has a higher bias towards her ideology. The net payoff for the consumer is given as:

$$U(i) - \alpha||i-\tilde{\imath}|| \qquad \ldots(1)$$

[7] To simply, if a *fake* news producer will receive an expected payoff of $E(\pi_1) = s(\pi_1) + (1-s)0$ and $E(\pi_2) = s(\pi_2) + (1-s)0$ for favorable and unfavorable news respectively.

[8] One can assume the contrary with the reasoning that cost of manipulating fake news to make it more believable is higher than producing true news. However we proceed in our model with assumption of higher research costs associated with production of true news.

Consumers would prefer to consume news that is closer to the true state of the world, i_0. Therefore consumers would be cautious about consuming fake news. A possible consumption of fake news will give them disutility which is given in our model as $\beta||i - i_0||$. The distance function $||i - i_0||$ shows the distance of the consumed information i from the 'true' or actual state i_0. Here, disutility received depends on degree of awareness, β. For an *informed* consumer, β would be higher and hence she would attach a higher disutility for possible consumption of *fake* news. The net payoff for consumers in this case is:

$$U(i) - \beta||i - i_0|| \quad \ldots(2)$$

Therefore consumer's payoff from his strategy of *accepting (A) or rejecting(R) favorable(F)* and *unfavorable(UF)* news can be summarized as:

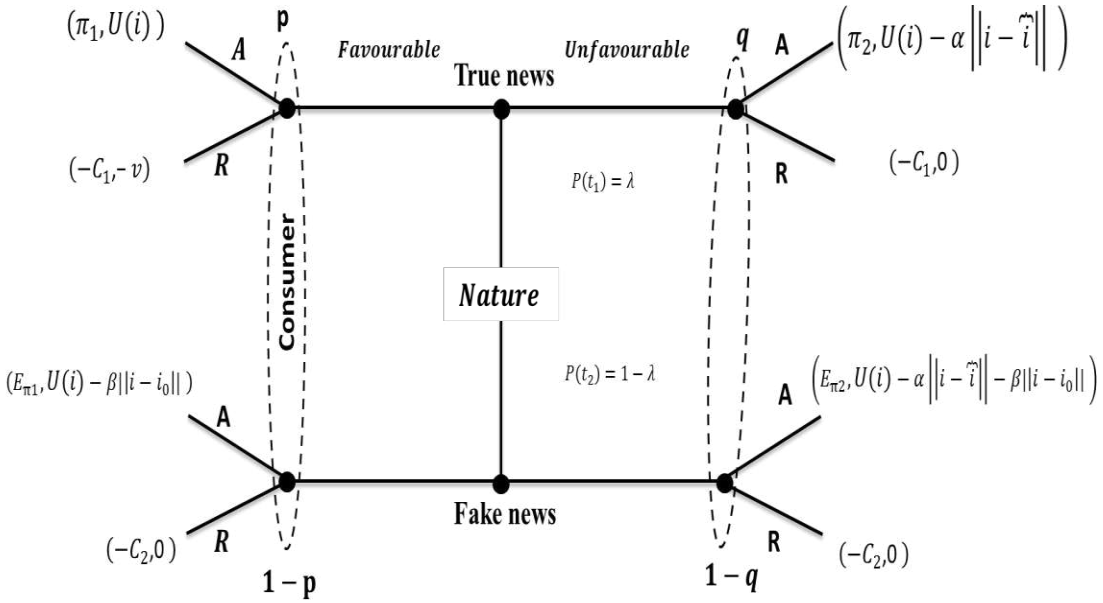
$$\mathrm{U(A|F)} = \begin{cases} U(i) - \beta||\mathrm{i} - \mathrm{i}_0||, & if\ favorable\ news\ is\ fake\ and\ \beta||\mathrm{i} - \mathrm{i}_0|| \geq 0 \\ U(i), & if\ favorable\ news\ is\ true \end{cases} \quad \ldots(3)$$

$$\mathrm{U(A|UF)} = \begin{cases} U(i) - \alpha||i - \tilde{\imath}|| - \beta||\mathrm{i} - \mathrm{i}_0||, if\ unfavorable\ news\ is\ fake, \beta||\mathrm{i} - \mathrm{i}_0|| \geq 0, \alpha||i - \tilde{\imath}|| \geq 0 \\ U(i) - \alpha||i - \tilde{\imath}||, if\ unfavorable\ news\ is\ true \end{cases} \quad \ldots(4)$$

On the other hand, if the consumer *rejects* a signal closer to her ideological beliefs despite being true, then she will incur a cost given by $v > 0$, which can be interpreted as disutility from *fear of missing out* on true information. Consumers may experience a similar sense of dissatisfaction when they miss out on true unfavorable news, given by k . However, the impact of missing out on favorable news is greater than the impact of missing out on unfavorable one, $v > k$. Without loss of generality, we assume $k = 0$.

The game can be represented in figure 1.

Figure 1: Structure of the signaling game between News Producer and Consumer



Source: Authors' Illustration

3.1 Categorization of consumers

The representative consumers vary with respect to the degrees of ideological preference and awareness. Therefore, it is important to categorize different consumers before proceeding forward to find PBNE for each such category. For informed consumers, β would be high enough for net payoff from possible consumption of fake news to be $U(i) - \beta\left||i - i_0|\right|$ <0. In the game, such consumers decide their optimal strategy by comparing the expected payoff from *accepting or rejecting.* However for uninformed consumers, $U(i) - \beta\left||i - i_0|\right|$ >0 since awareness level β is not high for such consumers. Therefore such consumer might end up *accepting* fake news since it is their dominant strategy irrespective of whether the signal is from *True* news or *fake* news producer. We find that the critical value of β to be given as $\hat{\beta} = \frac{U(i)}{||i - i_0||}$, obtained from $U(i) - \beta\left||i - i_0|\right| = 0$. Based on the critical value obtained we categorize the consumer as informed when $\beta > \hat{\beta}$ and uninformed when $\beta < \hat{\beta}$. Similarly, the critical value of α is obtained as $\hat{\alpha} = \frac{U(i)}{||i - \tilde{\imath}||}$ from $U(i) - \alpha\left||i - \tilde{\imath}|\right| = 0$, and categorize the consumers according to their strong ideological preference ($\alpha > \hat{\alpha}$) or weak ideological preference ($\alpha < \hat{\alpha}$). A consumer with a *strong* ideological sensitivity would not be too keen to consume any information against her ideology irrespective of the truthfulness of the information. Therefore, *reject* is her optimal strategy since the net payoff for consuming any information against ideology would be $U(i) - \alpha\left||i - \tilde{\imath}|\right| < 0$. Similarly, consumers with weak ideological sensitivity may *accept unfavorable* news since for them $U(i) - \alpha\left||i - \tilde{\imath}|\right| >$

0. However, whether their strategy to accept will be dominant depends on their awareness level.

The following lemma helps in categorizing the consumer with respect to awareness level *(informed or uninformed)* and ideological sensitivity *(weak or strong)* and then find the PBNE for consumers representative of each category.

3.1.1 Informed consumer with strong ideology ($\alpha > \hat{\alpha}$, $\beta > \hat{\beta}$)

Lemma1. *For informed consumer with strong ideological beliefs, in a signaling game* between consumers and news producers, *pooling equilibria are* $\left[FF, A\ R, p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, q\right]$ and $\left[UF\ UF, R\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, q\right]$ *implying that pooling holds for 'favorable' signal if* $p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$ *(for any* q*) and for 'unfavorable' signal if* $p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$ *(for any* q*),*$q \in [0,1]$

Proof: When both *types* of producers are giving *signals favorable* to the ideology, the payoff from playing the *strategy accept* for an *informed consumer* is given as: $U(i) > 0$ (for *favorable and true)* and $U(i) - \beta\left||i - i_0|\right| < 0$ (for *unfavorable and fake).* Since in this case there is no dominant strategy for consumer, therefore he decides his optimal payoff from comparing the expected payoffs from *accepting* and *rejecting.* The consumers are likely to *accept* if the updated Bayesian belief of consumers, $p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. We obtain a pooling equilibrium on *favorable signal (F)* since the producers have no incentive to deviate from their current strategy of producing favorable news, irrespective of consumers' response to off the path equilibrium strategy of unfavorable news, since $\pi_1 > \pi_2$.Thus pooling equilibrium for *favorable news* with receiver *accepting* hold.

Another PBNE for *informed consumers* are when both producers are sending *unfavorable signal.* Given that the consumers have *strong ideological preference, rejecting* becomes the *dominant strategy* for such consumers when served with *unfavorable* news. Pooling on *unfavorable signal (UF*) will hold if $p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$, where consumers optimal *strategy* is to *reject* even though the *signal* is *favorable*. Therefore the producers cannot do any better by

shifting to producing favorable news. The equilibrium is uninformative as the consumer *rejects* occurs regardless of the *type* of signal.

We obtain that among informed consumers with strong ideological sensitivity fake news may propagate only for favorable news as consumer cannot segregate the type of producer from the favorable signal they receive. In Spence's signaling model for a pooling equilibrium, posterior probability is equivalent to their prior even after updating their beliefs as consumers cannot segregate the signal from producers. Therefore one may say fake news propagates when consumers have a higher prior that favorable news is originating from true news sources. The pooling on unfavorable news is inconsequential as consumers optimal strategy there would be to reject irrespective of the type of signal making the equilibrium uninformative.

3.1.2 Informed consumer with weak ideology $(\alpha < \hat{\alpha}, \beta > \hat{\beta})$

Lemma 2. *For informed consumer with weak ideological beliefs, in a signaling game pooling equilibria are* $\left[FF, A\ A, p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v},\ q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}\right]$, $\left[FF, A\ R, p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v},\ q < \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}\right]$, $[UF\ UF, A\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v},$ $q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}$ *and* $[UF\ UF, R\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v},$ $q < \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}]$ *implying that consumer accept 'favorable' signal for any* $p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$ *and 'unfavorable' signal for any* $q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}$ *. Any Pooling at Unfavorable news will hold iff* $p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$.

Proof: Previously, we obtained that for *informed consumer* pooling equilibrium on *favorable* news hold and consumer accepts for any given q iff $p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. Therefore, similar to the previous exercise one can justify the PBNE $\left[FF, A\ A, p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v},\ q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}\right]$ and $\left[FF, A\ R, p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v},\ q < \frac{\beta||i-i_0||-(U(i)-\alpha||i-\bar{\imath}||)}{\beta||i-i_0||}\right]$.Hence with $p > \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$, consumers optimal strategy is to accept favorable signal. Hence, producers

will have no incentive to deviate to off the path equilibrium strategy of *unfavorable news* even if the consumer *accepts.*

From accepting unfavorable news, informed consumers with *weak* ideological sensitivity receives payoff given as: $U(i) - \alpha\left||i - \tilde{\imath}|\right| > 0$ (for *unfavorable and true)* and $U(i) - \alpha\left||i - \tilde{\imath}|\right| - \beta\left||\mathrm{i} - \mathrm{i}_0|\right| < 0$ (for *unfavorable and fake).* Since there is no dominant strategy, consumer decides his optimal strategy by comparing the expected payoffs. The consumer *accepts unfavorable news* when $q > \frac{\beta||i-i_0|-(U(i)-\alpha||i-\tilde{\imath}|)}{\beta||i-i_0||}$. If $p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$, then producers will have no incentive to shift to producing favorable news as consumers optimal response will be to *'reject'* and thus pooling equilibrium on *unfavorable news* holds. Even for this category of consumer we have an uninformative equilibrium in $[UF\ UF, R\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, q < \frac{\beta||i-i_0||-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}]$ where consumer is *rejecting* irrespective of the *type* of signal.

Here fake news propagates when pooling holds for favorable and unfavorable news with consumers accepting the signal. However, pooling equilibrium $[UF\ UF, R\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, q < \frac{\beta||i-i_0||-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}]$ is uninformative just like the previous case.

3.1.3 Uninformed consumer with strong ideology $(\alpha > \hat{\alpha}\ , \beta < \hat{\beta})$

Lemma 3. *For uninformed consumer with strong ideological beliefs, in a signaling game, an unique pooling equilibrium attained at* $[F\ F, A\ R, p, q]$ *implying that pooling holds for 'favorable' signal for any* p *and* q.

Proof: This refers to the situation when the representative consumer is not particularly aware about the presence of fake news and hence disutility she attaches to possible consumption of any *favorable fake* news is so low that $U(i) - \beta\left||i - i_0|\right| > 0$. Hence net-payoff from consuming *fake* news is positive. In such case, the consumer's *dominant* strategy is to *accept* for *favorable signal.* Since the consumer has a *strong* ideology, she would *reject* any *unfavorable signal,* irrespective of it being *true* or *fake.* Therefore, producers have no incentive to produce unfavorable news. Hence, here fake news propagates only for favorable signal as the pooling equilibrium holds.

2.1.4 Uninformed consumer with weak ideology $(\alpha < \hat{\alpha}, \beta < \hat{\beta})$

Lemma 4. *For uninformed consumer with weak ideology, in a signaling game, pooling equilibria are* $[F\ F, A\ A, p, q]$ *and* $[F\ F, A\ R, p, q]$ *implying that pooling sustains for 'favorable' signal for any* p *and* q.

Proof: We obtained that where the consumer though uninformed does not have extreme ideological preference, *accepting* remains optimal for any *favorable signal* irrespective of it being *true* or *fake.* Therefore pooling on *favorable signal* holds similar to the previous case. The consumers' response to the off-equilibrium path strategy becomes inconsequential because pooling at unfavorable news will never be sustainable. This is due to producers have incentive to shift to producing *favorable* news since $\pi_1 > \pi_2$. Therefore from lemma 3 and lemma 4, we conclude that for uninformed consumer pooling is most likely to sustain at favorable news.

Having established the pooling equilibrium for each category, it is imperative to reiterate that *fake news in the model propagates whenever pooling equilibrium holds.* This is because consumer cannot segregate between *true* and *fake* signals. A simpler interpretation is that consumer's prior beliefs remain unchanged despite receiving signal i.e. $p, q = \lambda$. Thus the pooling equilibrium implies a lack of information differentiation among the producers, leading the consumers to disregard the received *signals* and hence no updation of beliefs. This does not happen in case of a separating equilibrium since consumers can perfectly segregate the origin of the signals and hence there is a an complete Bayesian updation of posterior, therefore $p \neq \lambda$.

3.2 Perfect Bayesian Nash Equilibrium

Since we have obtained all the possible PBNEs from different categories, we can state the following propositions:

Proposition 1

Pooling equilibrium at favorable news with consumers accepting holds for all degrees of awareness level $(\beta \gtrless \hat{\beta})$ *and ideological sensitivity* $(\alpha \gtrless \hat{\alpha})$ *for any* $p \in \left[\frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, 1\right]$ *and* $0 < q < 1$.

Proof: Based on the critical values of α and β we categorize the population. From the lemmas we obtained that pooling on *favorable* news always holds for *uninformed* consumers.

However, for pooling on *favorable* news to hold in case of *informed* consumers posterior belief p must exceed $\frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. Hence pooling on *favorable* news will always hold for any degree of *awareness level* and *ideological sensitivity* for any $p \in [\frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, 1]$.

Proposition 2

Pooling equilibrium at unfavorable news holds only for informed consumer ($\beta > \hat{\beta}$) for any q and $p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. The consumer will accept unfavorable signal only when $q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}$.

Proof: Pooling at *unfavorable* news holds only for *informed* consumers. For pooling to hold at *unfavorable signal, p must be less than* $\frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$ so that producers have no incentive to shift to producing *favorable* news. Pooling on *unfavorable* news hold for *informed* consumer with *strong* ideology at $\left[UF\ UF, RR, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, q\right]$ and for *informed* consumer with *weak* ideology at $[UF\ UF, A\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$,

$q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}]$ and $[UF\ UF, R\ R, p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}, q < \frac{\beta||i-i_0||-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}]$.

Therefore, what we obtain is pooling on *unfavorable* news holds iff $p < \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. But consumer's decision to accept or reject the unfavorable signal will depend on q. Therefore, pooling at UF holds and consumer accepts the signal is met when $q > \frac{\beta||i-i_0||-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}$.

Proposition 3

Separating equilibrium does not hold for all category of consumers other than for informed consumer ($\beta > \hat{\beta}$) with strong ideology ($\alpha > \hat{\alpha}$) at p=0 and q=1, bearing resemblance to a babbling equilibrium.

Proof: When updated posterior beliefs of the consumer are tied at $p = 0$ and $q = 1$, i.e. *favorable* signal coming from *fake* news producer and *unfavorable* signal coming from *true* news producer, *informed* consumers with *strong* ideology optimally *reject* signals of both the producers. Therefore there is no incentive for the producers to deviate from the strategy they

are playing. Hence separating equilibrium holds. However, the separating equilibrium is not informative since the consumer finds it optimal to reject irrespective of the type of signal. Hence the equilibrium holds a resemblance to a babbling equilibrium setup where receiver's response is not likely to change irrespective of senders strategy.

Separating equilibrium does not hold for same category of consumer at $p = 1$ *and* $q = 0$. Given the posterior belief of consumer tied at $p = 1$ with *true* news producers sending *favorable* signal, the consumer optimal strategy is to *accept.* This gives incentive to the *fake* news producer to mimic the behavior of *true* news producer since given the belief of the consumer, she will *accept* any *favorable* as *true.* Hence, separating equilibrium does not hold at $p = 1$ and $q = 0$.

3.3 Drivers of PBNE: Behavioral factors

The objective of our paper is to determine the role of behavioral factors in influencing the consumption demand for fake news. Previously from the lemmas we obtained that fake news sustain whenever pooling equilibrium holds regardless of the type of signal. However, it is imperative to point out that the acceptance of fake news in a pooling equilibrium across different categories of consumers is driven by behavioral factors. In our model, we cover the behavioral aspects on the basis of informational utility of consumers, awareness level, fear of missing out on favorable information and ideological sensitivity.

a) Informational Utility

From proposition 1 and proposition 2 we obtained the pooling equilibrium condition on favorable and unfavorable news given by $p^* = \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$ and $q^* = \frac{\beta||i-i_0||-(U(i)-\alpha|i-\tilde{\imath}||)}{\beta||i-i_0||}$. Pooling equilibrium will hold and fake news will sustain in the system if $p > p^*$ or when $q > q^*$, hence the likelihood of a pooling equilibrium holding depends on p^* and q^* which itself depends on informational utility, $U(i)$. Intuitively, with rise in $U(i)$ pooling equilibrium is more likely to hold since credulous groups are likely to accept any signal irrespective of their validity (Campbell 2021).

Proposition 4

The likelihood of a pooling equilibrium increases with the rise in informational utility among consumers across categories, regardless of the type of signal.

Proof: From the pooling equilibrium condition obtained in p^* and q^*, we obtain that $\frac{\partial p^*}{\partial U(i)} < 0$ and $\frac{\partial q^*}{\partial U(i)} < 0$. This suggests that as the preference for information increases, the pooling equilibrium condition becomes less restrictive. This is because higher informational utility leads consumers to be more receptive to any signal irrespective of its type and validity. Hence it becomes more conducive for fake news to sustain in the system as pooling can now hold for both favorable and unfavorable signal for a lower pooling equilibrium condition $p^{**}(say) < p^*$ and $q^{**}(say) < q^*$ respectively.

We obtained in proposition 2, pooling at unfavorable news hold with consumers *accepting* for any $q > q^*$, where $q^* = \frac{\beta||i-i_0||-(U(i)-\alpha|i-\tilde{\imath}|)}{\beta||i-i_0||}$. Here q is function of ideological sensitivity and awareness parameter i.e. $q = q(\alpha, \beta)$. As we understand in a pooling equilibrium, prior beliefs are equal to posterior i.e. $q = \lambda = q(\alpha, \beta)$, therefore beliefs of the consumer depends on *ideological sensitivity* and *awareness level.* Therefore, our next propositions consider the role of ideological sensitivity and awareness on *acceptance* of *unfavorable* news.

b) Ideological Sensitivity

Proposition 5

The condition for pooling equilibrium at unfavorable news, $q > q^*$, where $q^* = \frac{\beta||i-i_0||-(U(i)-\alpha|i-\tilde{\imath}|)}{\beta||i-i_0||}$, *becomes more stringent with increase in level of ideological sensitivity*(α)*, given p<p*, where* $p^* = \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$

Proof: From proposition 2 we derived that *unfavorable* news is *accepted* only by *informed* consumer with *weak* ideology for any $q > q^*$, where $q^* = \frac{\beta|i-i_0|-(U(i)-\alpha||i-\tilde{\imath}||)}{\beta||i-i_0||}$. Therefore, consumers with weak ideology she will accept an unfavorable signal when $q > q^*$ unlike the ones with strong ideology who is likely to reject any non-confirmatory signal regardless of it being true or fake. Further, we obtain that $\frac{\partial q^*}{\partial \alpha} = \frac{||i-\tilde{\imath}||}{\beta||i-i_0||} > 0$ i.e. for any rise in *ideological sensitivity* parameter α, it influences the pooling equilibrium condition q^* to increase and

hence pooling on *unfavorable* news will now hold at a higher $q > q^{**} > q^{*}$, where q^{**}(say) is the new pooling equilibrium condition. This intuitively suggests that consumers with weak ideology will accept and pooling equilibrium will hold when they have a higher posterior belief that non-confirmatory signal coming from *true* news sources.

However this may not be a very optimal scenario in long run as with increasing ideological sensitivity, consumer will start behaving like a strong ideological type whose optimal action would be to reject when they receive non confirmatory signal irrespective of it being true or fake. It is intriguing to note that we will have a similar effect of a more stringent pooling equilibrium condition of unfavorable news with rise in awareness level. As we will obtain in the next proposition, with rise in awareness level of the consumer will accept any signal (confirmatory or non-confirmatory) when they are more certain about the source of the signal. Therefore, to restrict the propagation of fake news, we need to have the condition for pooling more stringent. Stringency raises the bar for accepting information, and sets a higher standard for the credibility and reliability of information that consumers are willing to *accept* and propagate. This acts as a safeguard against the inadvertent or intentional dissemination of inaccurate or misleading information. The subsequent propositions establish the influence of awareness on the stringency of the pooling equilibrium regarding *favorable* and *unfavorable news.*

c) Awareness

Proposition 6

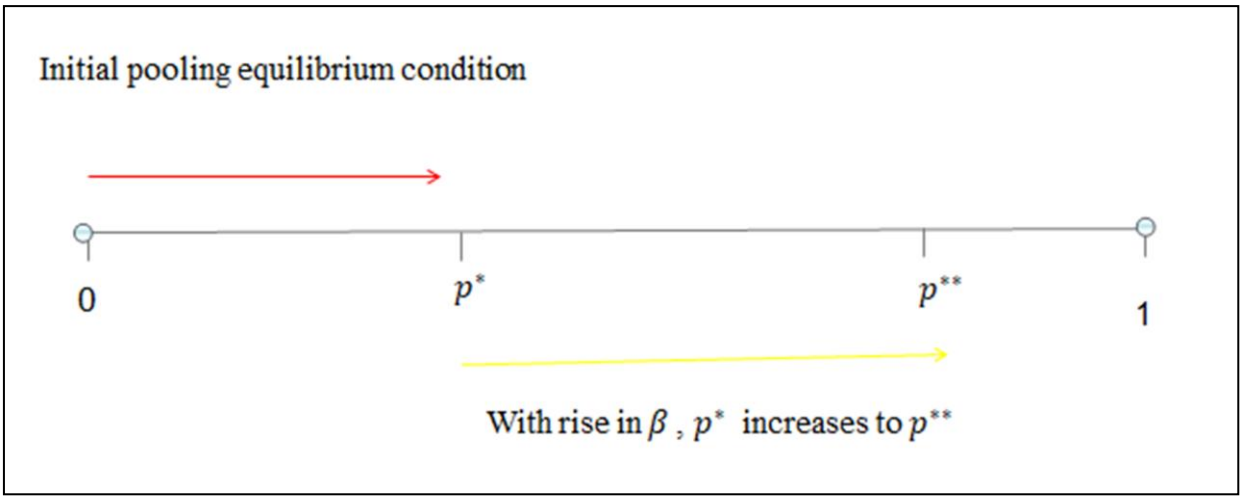
Increased awareness (β) *will make the pooling equilibrium condition for favorable* $(p > p^{*})$ *and unfavorable news* $(q > q^{*})$ *more stringent.*

Proof: We obtained previously that pooling equilibrium on *favorable* news holds for all uninformed consumers for any p. However, it holds for informed consumers only when $p > p^{*} = \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. Now the pooling equilibrium being a function of the *awareness* level β, we obtain that $\frac{\partial p^{*}}{\partial \beta} = \frac{(v+u)||i-i_0||}{(\beta||i-i_0||+v)^2} > 0$. This indicates that with increase in *awareness* parameter β, now a pooling equilibrium will hold only when the consumer's exhibit high degree of certainty regarding the source of the information i.e. consumers is likely to *accept* a *favorable signal* subject to posterior $p > p^{**} > p^{*}$, where p^{**}(say) is the new pooling equilibrium condition. As shown in figure 2, the posterior probability for pooling equilibrium

to hold on favorable news increases from p^* to p^{**}. It can be noted that the stringency condition serves to increase the threshold for acceptance, requiring higher credibility and reliability of information before consumers are willing to accept it. Consequently, as β increases, the posterior probability, $p^* \to 1$ potentially leading to a breakdown of the pooling equilibrium. With $p^* \to 1$ consumers are more inclined to differentiate between signals from the two producers, moving away from a homogeneous response.

Similarly we obtained from proposition 2 that pooling equilibrium on unfavorable news holds only for consumers with weak ideology. At the pooling equilibrium, they will accept unfavorable news for any $q > q^*$. Given q^*, we obtain that $\frac{\partial q^*}{\partial \beta} = \frac{((U(i)-\alpha||i-\bar{\imath}||)(||i-i_0||)}{(\beta||i-i_0||)^2} > 0$ which suggests that with rise in awareness level she will accept unfavorable news subject to an updated pooling equilibrium condition q^{**}.Therefore pooling at unfavorable news hold and consumer will accept for $q > q^* > q^{**}$. Hence the condition for pooling becomes stringent irrespective of the type of signal with increase in awareness level. Therefore, we can put forward that increasing the *awareness* of the population can help to break the pooling so that consumers can effectively discern and differentiate the *signals* sent by the producers.

Figure 2: Influence of increased awareness on p^*



Proposition 7

For a representative consumer with an awareness level of $\beta \geq \hat{\beta}$*, where* $\hat{\beta} = \frac{U(i)}{||i - i_0||} \in [a, b]$*, belonging to the cohort of population of* $\sigma = N\left(\frac{b-\hat{\beta}}{b-a}\right)$ *can restrict the chain of fake news.*

Proof: Previously, we had obtained a critical *awareness* level $\hat{\beta}$ beyond which consumers are *informed* and attaches higher disutility from possible consumption of *fake* news. Given a uniformly distributed knowledge level $[a, b]$ among a population of size N we can obtain the probability of awareness level for a representative consumer being greater than $\hat{\beta}$. Hence, the cohort of population that can identify fake news is given as $\mathrm{N}(\frac{\mathrm{b}-\hat{\beta}}{\mathrm{b}-\mathrm{a}})$. The condition for pooling equilibrium will be stringent for this cohort of consumers. Hence from the exercise we get exactly the cohort from the population who will be able to segregate signals as $p^* \to 1$ with increasing awareness level.

This cohort, while informed, is susceptible to fake news subject to the behavioral factor fear of missing out on favorable information. As discussed previously, beyond *awareness* certain behavioral factors„ intrinsic to the consumer may determine information consumption pattern[9]. A*cceptance* of pro-attitudinal *fake* news can continue if consumer's *fear of missing out* on *favorable* news (v) outweighs the disutility from fake news due to her awareness level.

d) Fear of missing out

Increase in v among informed individual $(\beta \geq \hat{\beta})$ makes it more likely for pooling equilibrium to hold. We obtained in the last proposition that rise in β makes the condition for pooling equilibrium to hold more stringent but rise in v dampens the effect of rise in β on p^*. In such scenario from policy standpoint it becomes intriguing to understand the optimal level of awareness which can shield consumers from such change in behavioral aspects. Hence just shifting β beyond $\hat{\beta}$ is not enough. We find a critical awareness level β^* beyond which rise in v will have no impact on stringency of the pooling equilibrium condition.

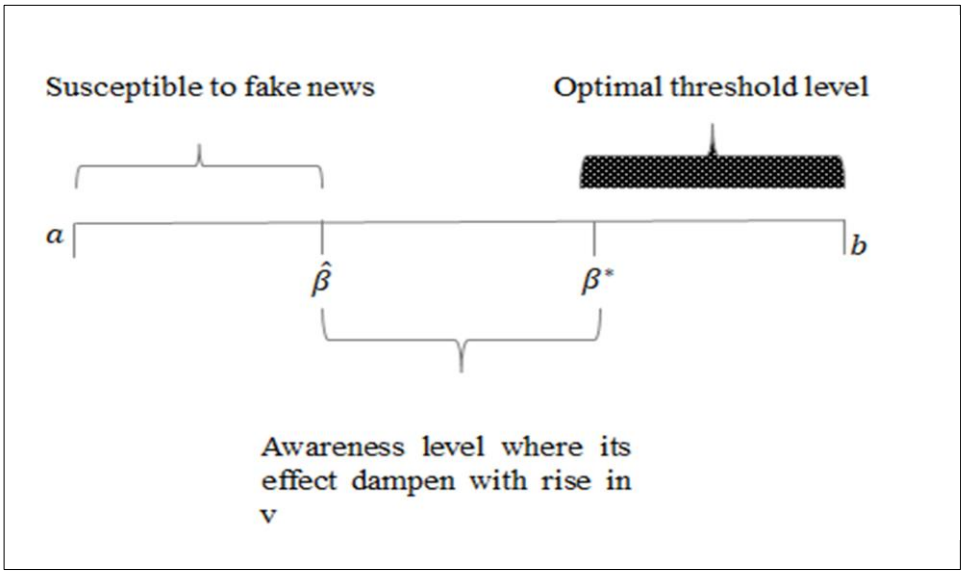
[9] This has previously been established in experimental study of Badrinathan (2021) where respondents with strong ideological preference for the incumbent party were unable to detect misinformation even after undergoing media literacy intervention.

Proposition 8 *If the awareness level of the consumer is* $\beta > \beta^*$ *where* $\beta^* = \frac{(2U(i)+v)}{||i-i_0||}$ *then* $\frac{\partial^2 p^*}{\partial v \partial \beta} > 0$ *i.e. rise in fear of missing out on information does not make the condition for pooling equilibrium,* p^* *any less stringent.*

Proof: We obtain a critical value of awareness level, $\beta^* = \frac{(2U(i)+v)}{||i-i_0||}$ beyond which $\frac{\partial^2 p^*}{\partial v \partial \beta} > 0$. For any *awareness* level preceeding β^*, we will have $\frac{\partial^2 p^*}{\partial v \partial \beta} < 0$ i.e. with rise in v, stringency on p^* due to an increased *awareness* level β diminishes.

From policy point of view, it is recommended to attain the critical optimal awareness threshold level beyond which any change in behavioral pattern, intrinsic to the consumer does not affect influence of awareness on pooling equilibrium condition p^*. Therefore while proposition 7 identify a critical $\hat{\beta}$ which make an consumer less susceptible to fake news, proposition 8 outlines a need for a critical awareness level β^* which is immune to changes behavioral aspects intrinsic to the consumer.

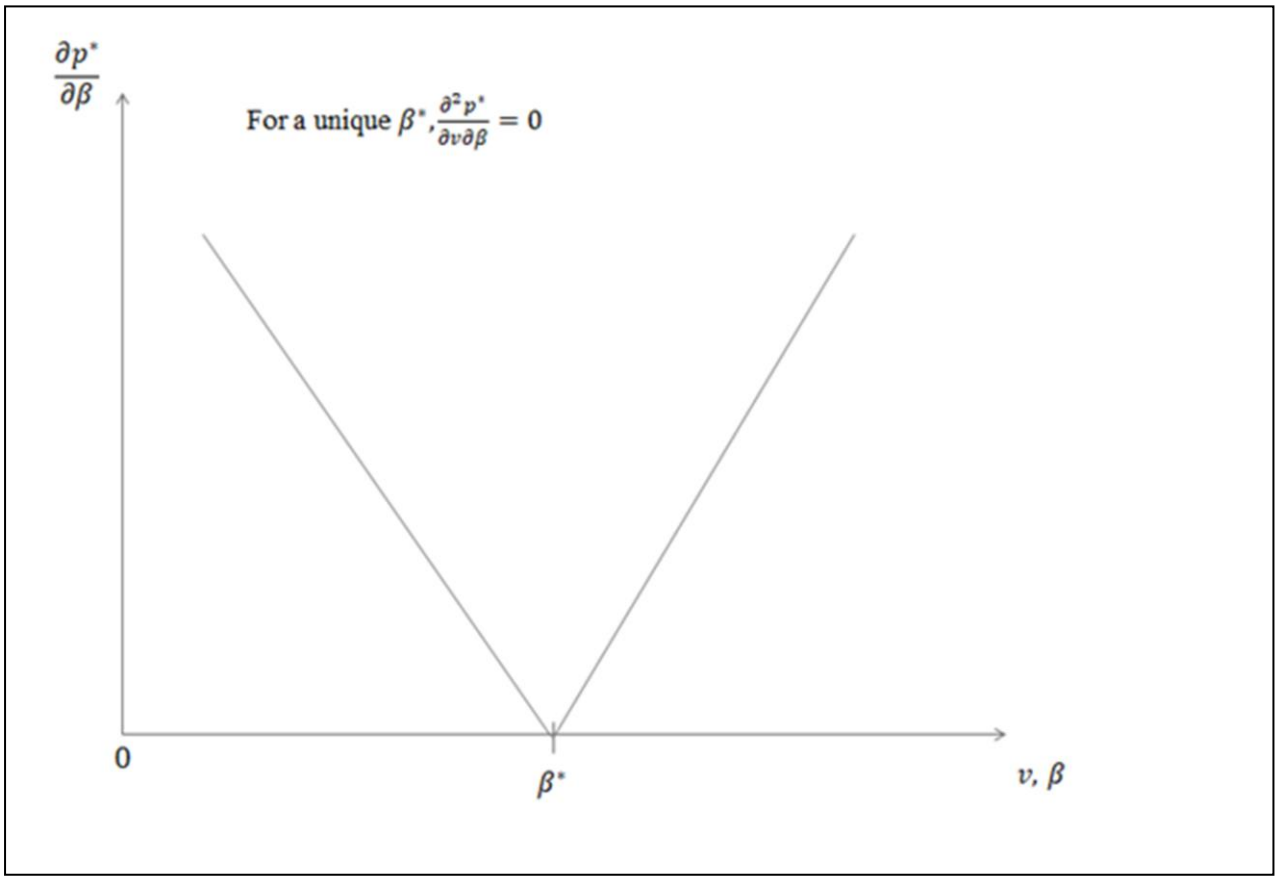
Figure 3: Different thresholds of awareness



Simulation results

From simulation in software R, we obtain a unique awareness level β^* beyond which impact of rise in v on p^* is ineffective. Specifically, when we fix a uniform distribution of $U(i) \in [0,0.7]$, $v \in [0.6,1]$ and ideology distributed over the interval $[0,1]$ with the true state $i_0 = 0.5$ we get a value of $\beta^* = 6.75$,beyond which for rise in v, $\frac{\partial p^*}{\partial \beta}$ does not fall. Hence p^* does not dampen for any awareness level beyond 6.75. In figure 3, we did a simulation on $\frac{\partial^2 p^*}{\partial v \partial \beta}$ with respect to β^* being 6.75. The left panel shows that $\frac{\partial p^*}{\partial \beta}$ has an unambiguous fall with a subsequent rise in v. On the right side, for $\beta > 6.75$, $\frac{\partial p^*}{\partial \beta}$ unambiguously increases. For 1000 iterations of such simulation, we obtained an array of $\beta^* \in [1.24,6.75]$. Hence to summarize our findings from figure 4, there exists a threshold level of *awareness* $\hat{\beta}$ beyond which consumers are considered *informed.* These consumers can detect *fake* news, however they are likely to be susceptible to *fake* news when there is *fear of missing out* on *true* information.

Figure 4: Optimal threshold of awareness



4. Conclusion

The literature on fake news and misinformation mostly encompasses the role of social media in their propagation, especially during elections. Seminal papers of Allcott and Gentzkow (2016) and Guess et al. (2018) identify the role of social media, particularly Facebook, as a source of misinformation. While this addresses the 'supply' side framework of fake news, our analysis puts forward the role of consumer's behavioral aspects such as informational utility, awareness, ideological sensitivity and fear of missing out on favorable news in determining 'demand' for fake news.

In our paper, we have categorized consumers based on their awareness level and degree of ideological sensitivity. Subsequently, we use Spence's (1973) job-signaling model to obtain the perfect bayesian nash for each such category. We obtain from our set of results that fake news propagates whenever the pooling equilibrium holds. There exists a separating equilibrium in our model but is not much informative and can be interpreted as 'babbling equilibrium' of a cheap talk game where receivers do not update their beliefs irrespective of the signal sent. To restrict the propagation of fake news, we analyze the role of behavioral factors in influencing the pooling equilibrium. We find that a pooling equilibrium is more likely to occur when there is a higher preference for information as reflected by a rise in informational utility or an increased fear of missing out on favorable information.

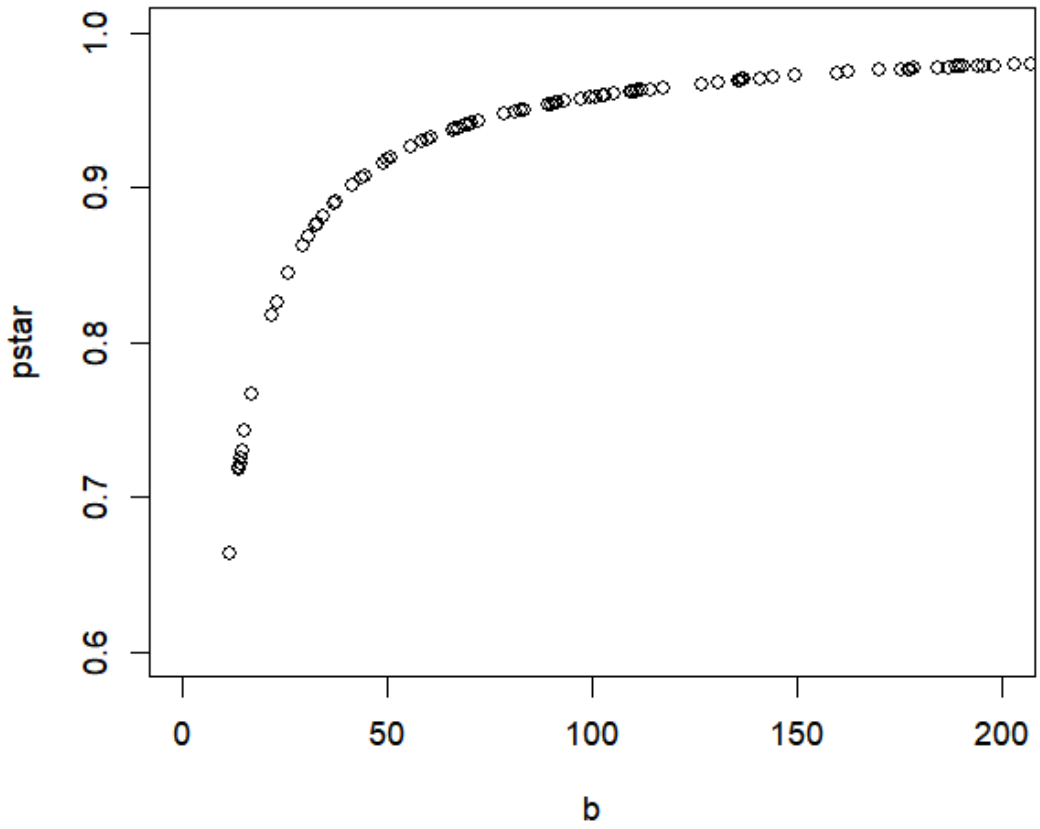
To break this pooling equilibrium we emphasize the role of awareness. We obtained that if the awareness level of a consumer is pushed beyond a critical level it reduces the propagation of fake news as it makes the pooling equilibrium condition stringent for both favorable and unfavorable signals. However, an increase in awareness may not necessarily lead to the breakdown of the pooling equilibrium. As the fear of missing out on favorable information increases among consumers, pooling is likely to hold even at a higher awareness level. Consequently, for policy effectiveness, we find a unique critical awareness level beyond which stringency of pooling equilibrium remains unaffected by any rise in fear of missing out. Hence, beyond this critical threshold of awareness level, the stringency of the pooling equilibrium condition remains unaffected from any behavioral aspect.

Fact-checking websites play an important role in increasing awareness regarding fake news. Since social media platforms are mostly unregulated and free for content generation, it becomes viable for politically motivated rumors. In 2018, the Government of India set up a committee to report on menacing instances of fake news. While fact-checking websites do

help in recognizing fake news, since inaccurate news is shared very frequently and in large numbers across social media, it becomes extremely cumbersome to fact-check the plethora of inaccurate news that exists in the system. It must also be pointed out that in general, fact-checking websites lag by delay for research purposes. In this period, inaccurate news is already spread by active users. Hence, such factors should also be kept in mind while considering fact-checking websites as a possible way to curb fake news. An interesting upcoming area of research could be how to accommodate this rising demand for the identification of fake news. Government intervention in detecting fake news may help the cause to an extent. However, the Government is not an apolitical body by default and hence it may not be unbiased in fact-checking. Therefore there is scope for private players to intervene in the market for fact-checking which will set in competition and make the process more efficient. There is a future scope of research in the field of the efficiency of fake news websites so that the awareness level of society attains the unique threshold level.

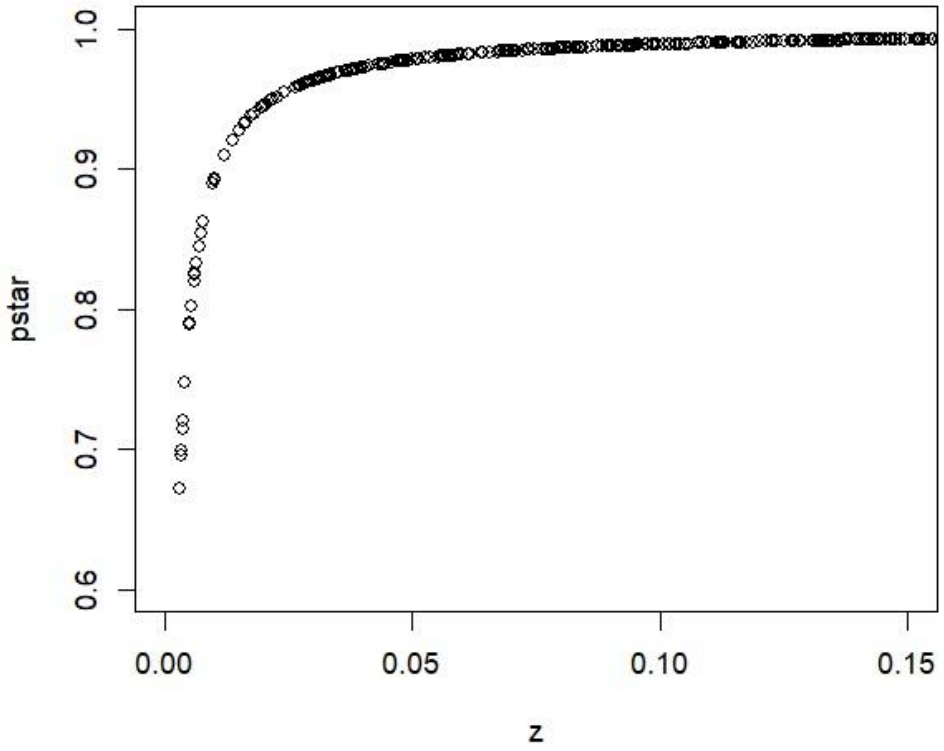
Appendix

1. Simulation results on relation of awareness parameter β on p^*



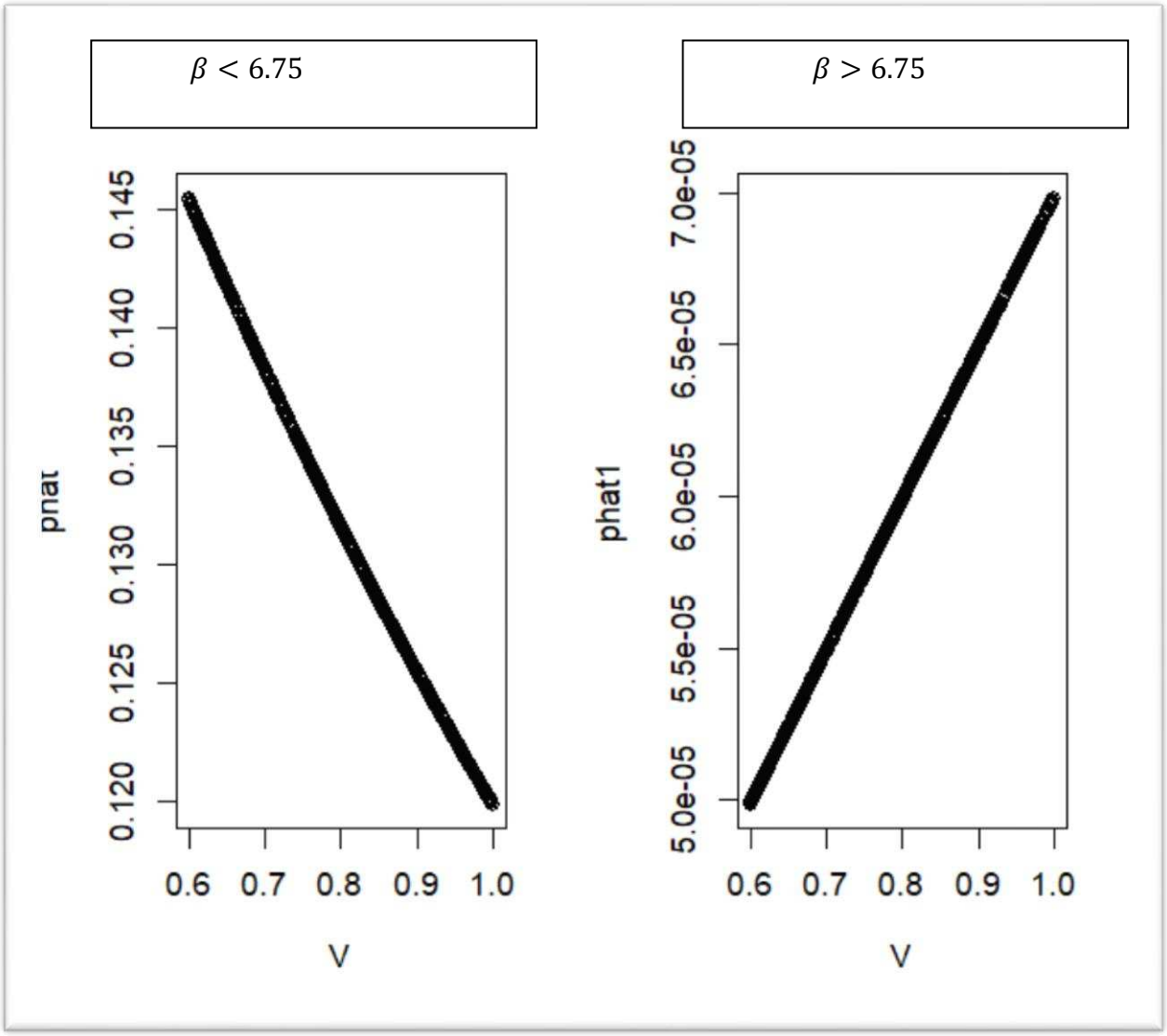
Here we have simulated the relation of awareness parameter β with p^*. As given from proposition 1, $p^* = \frac{\beta||i-i_0||-U(i)}{\beta||i-i_0||+v}$. We claimed in proposition 5 that with rise in awareness parameter β the condition for pooling equilibrium becomes more stringent. For uniformly distributed $U(i)$ and v in the the interval $[0,1]$ and β being determined as $\frac{U(i)}{||i-i_0||}$**.** From simulation of the results we obtain that as theoretically explained in proposition 5, the condition for pooling equilibrium p^* becomes more stringent.

2. *Higher the deviation of reported information from true state* i_0 *i.e.* $\left||i - i_0|\right|$*, more stringent will be the pooling equlibrium condition* p^*.



For fake news the reported information is away from the true state and consuming such information leads to a higher disutility. Therefore, ceteris paribus, as deviation of reported information from true state increases individuals are likely to accept any information only when they have a higher posterior belief about the credibility of the information. Hence rise in $\left||i - i_0|\right|$ makes the condition on pooling equilibrium more stringent.We obtained in corollary 2 that with rise in $\left||i - i_0|\right|$, the condition for pooling equilibrium p^* becomes more stringent. For a uniformly distributed $U(i)$, v and ideology over interval [0,1] and true state fixed at a level $i_0 = 0.5$ we obtain through simulation results that for a rise in z=$\left||i - i_0|\right|$, the condition for pooling equilibrium p^* is rising unambiguously.

Figure 5: Simulation result on proposition 8



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