Ideological Screening with Content Provision

Alice Peng-Ju Su*

Department of Economics, National Taipei University
August, 2023

Abstract

I recognize informative content as an endogenous presentation of evidence from a content provider to a unit mass of receivers with heterogeneous ideology. Through a content-providing contract, the provider screens the receiver's ideology with some content of various stances and credibility, which then shapes the posterior belief of the receiver. The characteristics of the optimal content-providing contract depend on whether the receiver regards his ideology and the content as information substitutes or information complements. Content provision exhibits a screening property if they are regarded as information substitutes due to the tradeoff between assertion and rent extraction. If they are considered information complements, content provision exhibits a bang-bang property due to the inconsistency between marginal value and willingness to pay for content. A tractable content-providing contract assuming a Bayesian receiver is examined. A receiver with sufficiently neutral ideology is induced to take the most credible content of the same stance; a receiver with intermediate ideology is induced to take a partially credible content of the same stance, with decreasing credibility in his ideology; a receiver with sufficiently extreme ideology is induced to take the neutral content for free. As a corollary, the posterior belief exhibits polarization across stances but convergence within.

Keywords: ideological screening, informative content, belief polarization
JEL: D82, D83, D86

*E-mail: apjs@gm.ntpu.edu.tw. Address: Department of Economics, National Taipei University, 151 University Road, Sanxia District, New Taipei City 237303, Taiwan. Financial support from the National Science and Technology Council, Taiwan (MoST 110-2628-H-305-003-MY2) is gratefully acknowledged.

1 Introduction

We resort to informative content, such as articles, podcasts, and advice, to facilitate our decisions or to simply gain knowledge on the state of the world. The credibility of content on the same issue can be vastly diverse and endogenously determined by the content provider. For instance, content with statistical evidence on birth rate, female education, and female labor market participation generally tells a more credible story on the declining birth rate than does content that quotes "an anonymous source." Providing content to a mass of content receivers whose prior ideologies are privately known, the credibility of content serves as a screening device. In addition to screening the prior ideologies of the content receivers, it also shapes the updated beliefs of the content receivers. The research questions in this paper are thus three-fold. What are the characteristics of the content-providing contract to screen the receivers' prior ideologies? What is the fundamental tradeoff? Would this screening mechanism induce congruent belief, or would it exacerbate the disagreement among the receivers?

Consider a content provider endowed with a rich set of raw evidence to be presented as content to a unit mass of readers (content receivers). The readers differ in prior ideologies, modeled as prior beliefs about the real state of the world, and these ideologies are private information to the readers. A reader demands content that shapes his posterior belief, given which he makes a non-contractible action choice. The provider decides what evidence to present and how to present the evidence in the content. This presentation of evidence determines the stance of the content as well as its credibility. Such stance and credibility can be committed through the abstract of the content. The provider proposes a content-providing contract as a menu of options, each consisting of credibility and stance of the full content committed through the abstract and associated payment. If the reader accepts the contract, he chooses an option in the menu and receives the full content. Contracts to provide informative content are not rare in reality. For instance, journals provide basic articles for free and an option to receive upgraded content with complete analysis at a price; providers of professional baseball statistics provide options for basic statistics or advanced statistics on the players' performance at a higher price. The reader of the content anticipates how his posterior belief will be updated upon choosing an option in the contract, and his posterior belief is updated after receiving the full content. The content screens the reader's prior ideology and shapes his posterior belief.

The reader's net value of content stems from the assertion about the state after receiving the content and depends on his prior ideology. If the most credible content

is provided to the readers, the net value of content is the highest for the provider to extract. The readers, however, disagree on such value. A reader of a stronger ideology has a lower net value of content and, hence, a lower willingness to pay for the content. Screening the reader's ideology thus relies on distortion of content credibility, which implements a lower level of assertion. The optimal content-providing contract exhibits a tradeoff between assertion and rent extraction.

How such tradeoff shapes the optimal content-providing contract depends on whether the readers regard their prior ideologies and the content as information substitutes or information complements. The content is an information substitute to the prior ideology if a reader with a stronger ideology updates his belief with a smaller magnitude upon receiving more credible content of the same stance. Bayesian belief is one example. The content and the prior ideology are information complements if otherwise.

If the content and the prior ideology are information complements, a reader with a stronger ideology expects a larger marginal value on the credibility of content supporting a given stance, but he is willing to pay less for the content. With these countervailing incentives, the optimal content-providing contract has a bang-bang property with three options: fully credible content of each stance at a fixed price and neutral content (which does not update belief) for free. Readers with extreme ideologies are induced to take the free neutral content, while those with intermediate ideologies take the fully credible content supporting the same stance as their prior ideology.

A more sophisticated screening is feasible when the content and the prior ideology are information substitutes. A reader with a stronger ideology resembles the "less efficient type" in traditional screening problems. He expects a lower marginal value on the credibility of content and is willing to pay less for the content. The optimal content-providing contract thus exhibits a screening property: decreasing credibility of content supporting each stance at a decreasing price for a reader who reveals a stronger ideology. Readers with more extreme ideologies are induced to take the less credible content at lower prices, while those with relatively intermediate ideologies take the more credible content at higher prices.

A tractable solution to the optimal content-providing contract can be found with Bayesian beliefs. Readers with Bayesian beliefs regard the content and their prior ideologies as information substitutes. The reader with a neutral prior ideology resembles the "most efficient type" in traditional screening problems. The optimal content-providing contract is symmetric and exhibits decreasing credibility of content supporting each stance for a reader who reveals a stronger ideology. The ex-ante neutral reader is indifferent between the fully credible content of each stance at the highest

price. Readers with relatively intermediate ideologies are induced to take the more credible content of the same stance at higher prices, while readers with sufficiently extreme ideologies are induced to take the neutral content for free. This optimal contract exhibits the property of freemium: basic content for free and upgraded content at higher prices, which is consistent with the previous examples. In addition, a reader under this screening contract is induced to take an option that conforms to his prior ideology. Given Bayesian updating, he is more asserted about the state of the world after reading the full content. For a reader with a relatively neutral prior ideology is induced to take the content with higher credibility, his posterior belief is affected by the content to a greater extent. The posterior beliefs of the readers thus exhibit polarization across stances but convergence within each stance to a more asserted belief.

1.1 Literature

Content as a source of information, the paper is most related to contracting for information products with privately known prior beliefs.[1] Modeling information products as experiments, Bergemann, Bonatti, and Smolin (2018) characterize the optimal contract on experiments that generate signals regarding the true state of nature, with asymmetric information on the agent's prior information. With binary prior, it is optimal to provide a fully informative experiment for the less priorly informed type and a partially informative experiment for the better priorly informed type of agent. With continuous prior, the optimal experiment is a step function with some pooling, prescribing a fully informative experiment for the agent with intermediate prior beliefs and a non-informative experiment for the agent with extreme prior beliefs. Not only are economists interested in contracting for data/experiments, but it is also a rising topic in information science. Babaioff, Kleinberg, and Leme (2012), Chen, Xu, and Zheng (2020), and Liu, Shen, and Xu (2021) are among the recent studies on data selling mechanisms. The former two show that the optimal mechanism can be computed in polynomial time, and it resembles a consulting mechanism; the latter characterizes a closed-form solution. On the other hand, Eső and Szentes (2007) study the consulting contract between a consultant (advice provider) and a client, with asymmetric information on how the client evaluates the advice. The optimal contract specifies a

[1] This belongs to a broader category of literature on trading information/data, e.g., Taylor (2004), Bergemann and Bonatti (2015), Kastl, Pagnozzi, and Piccolo (2018), and references therein. In these papers, the trading partners do not have asymmetric information except the piece of information being traded.

probability for the consultant to check the signal of the real state. They show an equivalence result regardless of whether the consultant perfectly or imperfectly observes the signal.[2]

Content in the current context resembles experiments/advice in the above literature in the sense that these "information products" have a quality (here, credibility) and positioning (here, stance) dimension, unlike usual physical goods. The fundamental difference between content provision and data/information provision lies in the following. It is the experiment (or the adviser's action to check the signal) that is being contracted in the above research. Signal realizes after the contract is signed, and the agent updates his belief and takes action based on the realization of signals. The experiment designer (or adviser) commits to the accuracy of the signal-generating experiment instead of the realization of signals. Ex-ante upon contracting, the agent anticipates how informative regarding the true state he will be after the experiment. The value of the experiment comes from its informativeness. In the current context, the content provider is endowed with some raw evidence (signals) before contracting. It is the presentation of the evidence that is being contracted. The agent's updated belief and action depend on the content presented to him in the contract. The content provider commits to the credibility of the presented content instead of the correlation between the presented evidence and the true state. Upon contracting, the agent anticipates how his posterior belief will be updated after reading the full content. The value of the content comes from a more affirmative belief it induces. Implications of belief polarization can be drawn.[3]

Characterization of content that screens the agent's prior belief and shapes the posterior belief, the paper shares a similar interest with the literature on belief polarization, e.g., Suen (2004), Benôit and Dubra (2019), Gentzkow, Wong, and Zhang (2021), and Kartik, Lee, and Suen (2021). These papers mainly focus on how the agent chooses his source of information or how the agents process or interpret the same piece of information differently, which leads to ex-post belief polarization. They focus on the demand side of information. I emphasize the design of content that screens the prior ideology and shapes the posterior belief, i.e., the supply-side story. With Bayesian belief, implication on belief polarization sustains across stance, while

[2]Krishna and Morgan (2008), Che and Kartik (2009), and Mitchell (2021) study advice/opinions as information disclosure. There is no asymmetric information in these papers beyond the opinions/advice to be disclosed. In addition, the informed adviser derives utility directly from the decision maker's action.

[3]Technicality-wise, the agent's payoff in the former is linear in the experiment given Bayesian belief. In contrast, in the current model, it is generally non-linear in the content, even under Bayesian belief.

belief convergence is present within stance.

Modeling ideology as heterogeneous prior beliefs on the true state, this paper is also related to the literature with uncommon prior, with different research questions. To list a few, Yildiz (2003) studies bargaining with uncommon prior regarding the order of proposal; Eliaz and Spiegler (2006) studies exploitative contract to screen diversely naive consumers, modeling naivete as uncommon prior; Sandroni and Squintani (2007) studies insurance contract when the insuree has biased belief on his level of risk; Eliaz and Spiegler (2008) and Grubb (2009) study price discrimination with over-confident consumers.

Content as a channel to deliver information, content provision may seem related to the literature on information design pioneered by Kamenica and Gentzkow (2011). Bergemann and Morris (2019) thoroughly review the literature in a unified framework. Recently, Kolotilin, Mylovanov, Zapechelnyuk, and Li (2017) and Min (2021) have incorporated screening into the persuasion mechanism. The content provider in this paper differs from the information designer in the sense that she does not derive utility directly from the true state or the content receiver's action. Conceptually, the content provider has no inherent incentive to "persuade" the receiver. The research questions are different. These papers are devoted to studying the optimal information mechanism to influence the receiver's behavior, whereas I focus on the optimal content provision to screen the receiver with heterogeneous prior ideology and how such content shapes the posterior belief of the receiver.

2 Model

The unknown future state of the world can be one with a new regime or one where the status quo remains. A content provider (principal) is endowed with a rich set of raw evidence on the future state of the world, some pieces of evidence in favor of each state. She is to form a contractual relationship with a unit mass of independent readers (agents) to deliver content regarding the future state of the world.[4] Upon reading the content provided, the reader updates his belief from his intrinsic ideology and takes a non-contractible action $a \in \{0, 1\}$ before the future state is realized. The action will generate one unit of expected value to the reader if action 0 is taken when the status quo remains or if action 1 is taken when the world has a new regime, zero expected

[4]The content is not restricted to written articles; it also includes videos, podcasts, and other formats that provide manipulated information. The readers can be any form of content consumers. I abuse the term reading just for ease of expression.

value otherwise. The content provider has no direct interest in the realization of the state or the reader's action.

The content provider is able to choose what and how to present the evidence on the new regime in the content. The presented evidence induces a belief that with probability $q \in [0,1]$, it is correct that the future state of the world will be in a new regime. We can interpret this probability as both the stance of the content and its credibility. A sufficiently small q implies credible pro-status-quo evidence, while a sufficiently high q implies credible pro-new-regime evidence.[5] For example, detailed content with some statistical analysis in favor of the new regime is of higher credibility than a quote from "an anonymous source" of the same stance. For another example, the content provider can quote experts from a conservative or a liberal think tank to develop content of different stances at comparable credibility. The stance and credibility of the content q is contractible through an abstract of the full content along with an associated transfer t from the reader to the content provider.[6] For instance, the provider can commit in the abstract that the full content will include an analysis using data collected by a specific think tank.

The reader's intrinsic ideology is modeled as a privately known prior belief that, with probability ϕ, the world will be in a new regime. The probability distribution of the ideology $F(\phi)$ is common knowledge.[7] Upon contracting, the reader can infer from the abstract the stance and credibility of the content. His belief is updated upon reading the full content, that with probability $\sigma(\phi, q)$ the world will be in a new regime, e.g. by Bayesian updating $\sigma(\phi, q) = \frac{\phi \cdot q}{\phi \cdot q + (1-\phi)\cdot(1-q)}$. The setup of stance and credibility of content and the heterogeneous intrinsic ideology is based on the implicit assumption that the readers have a consensus on the credibility of content, but they disagree on the value of the same credibility due to different prior beliefs. For ease of expression, define the content such that the reader of any ideology does not change his belief upon reading the full content as the "commonly recognized neutral content," denoted as $\tilde{q}$ such that $\sigma(\phi, \tilde{q}) \equiv \phi$. For example, $\tilde{q} = \frac{1}{2}$ with Bayesian belief. Assumption 1 on the posterior belief is made throughout the paper.

[5] With binary states, evidence on the new regime with a very small probability of being correct is equivalent to evidence on the status quo with a very high probability of being correct. It is modeling equivalent to assume that the provider provides evidence on the status quo that is correct with probability $1 - q$.

[6] I focus on paid content here. These can be found in paid articles following an abstract, online videos available only to paid members, etc. For free content sponsored by ads, please refer to Mitchell (2021).

[7] Distribution of the raw evidence does not matter here as long as it is common knowledge. The intrinsic ideology can be viewed as an interim belief updated from the known distribution of raw evidence that the provider has.

Assumption 1. *The reader's posterior belief* $\sigma(\phi, q) \in [0, 1]$ *is such that*

1. *There is some commonly recognized neutral content.*
2. *The posterior belief* $\sigma(\phi, q)$ *is increasing in* q *at any* ϕ*.*
3. *The posterior belief* $\sigma(\phi, q)$ *is increasing in* ϕ *at any* q*.*

The first assumption implies that the readers have a consensus on what a neutral stance is. Along with the second assumption, it implies that any $q > \tilde{q}$ indicates a stance closer to the new regime, and it is more credible with a higher q; symmetrically, any $q < \tilde{q}$ indicates a stance closer to the status quo, and it is more credible with a lower q. The third assumption implies that readers of different ideologies reading the same content do not update their beliefs in contrast to their prior ideologies. Reading the same content, a reader with an ideology closer to the new regime has an updated belief closer to the new regime. Bayesian belief satisfies Assumption 1 with $\tilde{q} = \frac{1}{2}$.

To focus on how the content screens the intrinsic ideology and shapes the posterior belief, I assume that the cost of content provision is sufficiently small and independent of the stance and credibility of content, normalized to zero. One can consider that the cost of raw material collection has been sunk when the content provider decides what evidence to present in the content. This zero-cost assumption implies an extreme benchmark with commonly known prior belief ϕ, that it is optimal to provide the most credible content on the status quo ($q = 0$) or on the new regime ($q = 1$) to the reader of any ideology at his maximum willingness to pay for such extreme content.

Given a contract with content q and transfer t, the content provider's payoff is given by $\pi(q, t) = t$, without intrinsic preference on the realization of the future state or on the reader's action. The reader's expected payoff with updated belief $\sigma(\phi, q)$ before the choice of action is given by $u(q, t, a|\phi) = \sigma(\phi, q) \cdot \mathbf{1}_1 + (1 - \sigma(\phi, q)) \cdot \mathbf{1}_0 - t$, with $\mathbf{1}_a$ being an indicator function on future payoff at action $a \in \{0, 1\}$. Without signing the content-providing contract, the content provider earns a zero reservation payoff. The reader has no other source of information and chooses his action based on his intrinsic ideology. The reader's expected payoff with his prior belief before the choice of action is given by $v(a|\phi) = \phi \cdot \mathbf{1}_1 + (1 - \phi) \cdot \mathbf{1}_0$.

With asymmetric information on ideology and commitment to the credibility of content, the content-providing contract consists of options to screen the reader's ideology. By the revelation principle, denote the contract as a direct revelation mechanism $\mathbb{C} = \{(q(\hat{\phi}), t(\hat{\phi}))\}$, where $\hat{\phi}$ is the revealed ideology. The content provider designs

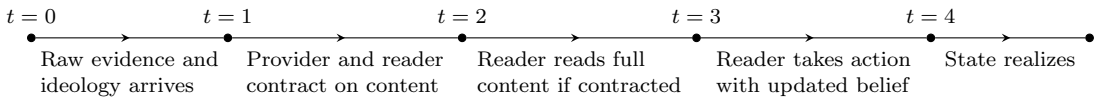

Figure 1: Timeline

the contract to induce the reader to truthfully reveal his ideology such that $\hat{\phi} = \phi$ in equilibrium.

The timeline of the game is given as follows and in Figure 1. The content provider is endowed with some raw evidence, and the reader is informed of his ideology before the contract proposal. The content provider proposes the take-it-or-leave-it contract $\mathbb{C}$, which is the only contract they can sign. The reader accepts or rejects the contract. If the reader accepts the contract, he chooses an option in $\mathbb{C}$ following his acceptance. Payment $t(\hat{\phi})$ is made, and the reader reads the full content of stance and credibility $q(\hat{\phi})$. After reading, the reader's belief $\sigma(\phi, q(\hat{\phi}))$ is updated based on his ideology and the chosen content. If the reader rejects the contract, his belief remains at his prior; no other content is available. After contracting for content (or not), the reader chooses an expected payoff maximizing action based on his updated belief. Upon reading the full content, the reader takes $a = 1$ if $\sigma(\phi, q(\hat{\phi})) \geq 1 - \sigma(\phi, q(\hat{\phi}))$ and action $a = 0$ if otherwise. His expected payoff from the option $(q(\hat{\phi}), t(\hat{\phi}))$ is $u(q(\hat{\phi}), t(\hat{\phi})|\phi) \stackrel{\text{def}}{=} \max\{\sigma(\phi, q(\hat{\phi})), 1 - \sigma(\phi, q(\hat{\phi}))\} - t(\hat{\phi})$. Without contracting for content, the reader takes action $a = 1$ if $\phi \geq 1 - \phi$ and action $a = 0$ if otherwise. His expected payoff based on his ideology is $v(\phi) \stackrel{\text{def}}{=} \max\{\phi, 1 - \phi\}$. State of the world and actual payoff realize afterward.

3 Content-Providing Contracts

The reader is willing to accept the content-providing contract given truthful revelation if the expected payoff based on the updated belief is higher than the expected payoff based on the prior belief, i.e. if the following individual rationality constraints hold for all ideology types,

$$u(\phi) \stackrel{\text{def}}{=} \max\{\sigma(\phi, q(\phi)), 1 - \sigma(\phi, q(\phi))\} - t(\phi) \geq \max\{\phi, 1 - \phi\} \quad \forall \phi.$$

The reader has incentive to reveal his true ideology if truthful revelation is expected payoff maximizing, i.e. if the following incentive compatibility constraints hold for all

ideology types,

$$u(\phi) \geq \max\{\sigma(\phi, q(\hat{\phi})), 1 - \sigma(\phi, q(\hat{\phi}))\} - t(\hat{\phi}) \quad \forall \phi.$$

The content provider's contracting problem is to maximize her expected payoff subject to the above individual rationality and incentive compatibility constraints, i.e.,

$$\max_{\mathbb{C}} \int_0^1 [t(\phi)] dF(\phi)$$

subject to $u(\phi) \geq v(\phi)$ and $u(\phi) \geq u(q(\hat{\phi}), t(\hat{\phi})|\phi)$ for all $\phi \in [0, 1]$.

For explanatory clarity, denote the options in the contract that induce $\sigma(\phi, q(\phi)) > 1-\sigma(\phi, q(\phi))$ as $\{(q_1(\phi), t_1(\phi))\}$ and the options that induce $1-\sigma(\phi, q(\phi)) > \sigma(\phi, q(\phi))$ as $\{(q_0(\phi), t_0(\phi))\}$. The former can be interpreted as content credibly supporting the new regime, while the latter as content credibly supporting the status quo. Expected payoffs implemented by the contract are denoted as $u_1(\phi) \stackrel{\text{def}}{=} \sigma(\phi, q_1(\phi)) - t_1(\phi)$ and $u_0(\phi) \stackrel{\text{def}}{=} 1 - \sigma(\phi, q_0(\phi)) - t_0(\phi)$ respectively. A reader with prior ideology $\tilde{\phi}$ is said to be ex-post indifferent (after reading the full content but before the realization of the true state) between $(q_1(\tilde{\phi}), t_1(\tilde{\phi}))$ and $(q_0(\tilde{\phi}), t_0(\tilde{\phi}))$ if $u_1(\tilde{\phi}) = u_0(\tilde{\phi})$.

Characteristics of an incentive compatible content-providing contract depend on whether the reader regards the content as a substitute or a complement to his prior ideology in information provision.

Definition 1. The reader regards the content as an information substitute to his prior ideology if $\frac{\partial^2 \sigma(\phi, q_1)}{\partial q_1 \partial \phi} < 0$ and $\frac{\partial^2 (1-\sigma(\phi, q_0))}{\partial q_0 \partial \phi} < 0$. Ideology and content are regarded as information complements if $\frac{\partial^2 \sigma(\phi, q_1)}{\partial q_1 \partial \phi} > 0$ and $\frac{\partial^2 (1-\sigma(\phi, q_0))}{\partial q_0 \partial \phi} > 0$.[8]

Lemma 1. *An incentive compatible content-providing contract is such that $q_i'(\phi) \leq 0$ for $i = 0, 1$ and $t_1'(\phi) \leq 0 \leq t_0'(\phi)$ if ideology and content are information substitutes. If ideology and content are information complements, an incentive compatible content-providing contract is such that $q_i'(\phi) \geq 0$ for $i = 0, 1$ and $t_1'(\phi) \geq 0 \geq t_0'(\phi)$.*

Proof. Appendix A1. □

Define the net value of content as the difference between posterior belief and prior ideology, $\max\{\sigma(\phi, q(\phi)), 1-\sigma(\phi, q(\phi))\} - \max\{\phi, 1-\phi\}$. If prior ideology and content are information substitutes, a reader with a stronger ideology has a smaller marginal

[8] Satisfaction of either information substitutes or information complements coincides with the single-crossing property assumed in traditional screening.

value of content supporting a given stance. For a reader who is induced to take the content credibly supporting the new regime (respectively, the status quo), his marginal willingness to pay for the more credible content is lower if he has a stronger prior belief of the new regime (respectively, status quo). The incentive compatible contract thus has non-increasing credibility and transfers in stronger ideological types. If prior ideology and content are information complements, a reader with a stronger ideology has a larger marginal value of content supporting a given stance. For a reader who is induced to take the content credibly supporting the new regime (respectively, the status quo), his marginal willingness to pay for the more credible content is higher[9] if he has a stronger prior belief of the new regime (respectively, status quo). The incentive compatible contract thus has non-decreasing credibility and transfers in stronger ideological types.

A reader with a stronger prior ideology has a higher expected payoff without the content and, hence, a lower net value of content. He is willing to pay less for the content of any credibility. To the extreme, a reader who is absolutely certain about the new regime or the status quo is unwilling to pay a positive transfer for any content. The profit-maximizing content provider thus provides the commonly recognized neutral content for free to at least the most extreme ideological types of readers.

Lemma 2. *The optimal content-providing contract satisfies binding individual rationalities for at least the readers with the most extreme ideologies* $\phi = 1$ *and* $\phi = 0$.[10]

Proof. Appendix A2. □

For a reader with an ideology closer to the new regime (status quo) than the ex-post indifferent type, the optimal contract implements the posterior belief towards the new regime (status quo). Relative to the ex-post indifferent type, the optimal contract provides content reaffirming the reader's belief.

Lemma 3. *It is not optimal for the content provider to induce the reader of prior ideology* $\phi > \tilde{\phi}$ *to take* $\{(q_0(\phi), t_0(\phi))\}$ *and the reader of ideology* $\phi < \tilde{\phi}$ *to take* $\{(q_1(\phi), t_1(\phi))\}$. *The optimal contract must not have* $q_0(\phi) > \tilde{q}$ *or* $q_1(\phi) < \tilde{q}$.

Proof. Appendix A3. □

By the envelope theorem of the reader's truthful revelation, $u_1'(\phi) = \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} > 0$ and $u_0'(\phi) = \frac{\partial (1-\sigma(\phi, q_0(\phi)))}{\partial \phi} < 0$, incentive compatible contract implements a higher

[9] His total willingness to pay for the content is lower, however, given a lower net value of content.

[10] For general contracting with type-dependent participation constraints, please refer to Lewis and Sappington (1989), Maggi and Rodríguez-Clare (1995), and Jullien (2000).

expected payoff for a reader whose prior ideology is closer to the implemented stance. To implement the updated belief towards the status quo for a reader with an ideology closer to the new regime than the ex-post indifferent type, it takes a negative transfer to satisfy incentive compatibility. The content provider can be better off by providing the commonly recognized neutral content for free, which is incentive feasible by construction, to avoid the negative transfer.

Given Assumption 1, if a content that is closer to the new regime than the commonly recognized neutral content but credibly suggests the status quo to a reader of type $\phi < \tilde{\phi}$, i.e., $q_0(\phi) > \tilde{q}$, this content reduces the reader's updated belief of the status quo from his prior ideology. The reader is willing to take this less valuable content only if it is at a negative transfer, which is not optimal for the content provider. The content provider can be better off proposing the commonly recognized neutral content at zero transfer for these types of readers instead, which is inherently incentive feasible. Symmetric reasoning holds for the suboptimality of $q_1(\phi) < \tilde{q}$.

Given the above three lemmas, the implemented payoff has $u_1(\phi) = 1 - \int_{\phi}^{1} \frac{\partial \sigma(x, q_1(x))}{\partial x} dx$ for $\phi \geq \tilde{\phi}$ and $u_0(\phi) = 1 + \int_{0}^{\phi} \frac{\partial (1 - \sigma(x, q_0(x)))}{\partial x} dx$ for $\phi \leq \tilde{\phi}$. By definition of ex-post indifference, $u_1(\tilde{\phi}) = u_0(\tilde{\phi})$ implies $\int_{\tilde{\phi}}^{1} \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} d\phi + \int_{0}^{\tilde{\phi}} \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} d\phi = 0$. The reduced contracting problem for the content provider is

$$\max_{q(\phi), \tilde{\phi}} \int_{0}^{1} \mathbf{1}_{\phi \geq \tilde{\phi}} \cdot \left(\sigma(\phi, q_1(\phi)) - \left(1 - \frac{F(\phi) - F(\tilde{\phi})}{f(\phi)} \cdot \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} \right) \right) + \mathbf{1}_{\phi \leq \tilde{\phi}} \cdot \left(1 - \sigma(\phi, q_0(\phi)) - \left(1 + \frac{F(\tilde{\phi}) - F(\phi)}{f(\phi)} \cdot \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} \right) \right) dF(\phi)$$

subject to $q_1(\phi) \in [\tilde{q}, 1]$, $q_0(\phi) \in [0, \tilde{q}]$, and $q_i'(\phi) \leq 0$ for $i = 0, 1$ if ideology and content are information substitutes or $q_i'(\phi) \geq 0$ if ideology and content are information complements.

Noticeable from the reduced contracting problem, the content provider faces a tradeoff between assertion and rent extraction. The reader's expected payoff maximization and risk neutrality imply the preference for assertion over uncertainty. The willingness to pay for the most credible content is the highest, but such willingness to pay differs across readers of different ideologies. Reducing content credibility to the reader of a stronger ideology, who also has a lower willingness to pay for higher credibility, allows the content provider to profit from the reader with a relatively neutral ideology. Distortion on the credibility is necessary to screen the reader's prior ideology. Such distortion depends on whether content and ideology are information substitutes

or information complements. If content and ideology are information substitutes, the optimal contract is characterized in Proposition 1, given Assumption 2.

Assumption 2. *Inverse hazard rate weighted by information substitutability is monotone:* $\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)} \cdot \frac{\partial^2 \sigma(\phi,q_1)}{\partial \phi \partial q_1}$ *is decreasing in* ϕ *for* $\phi > \tilde{\phi}$ *and* $\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)} \cdot \frac{\partial^2 (1-\sigma(\phi,q_0))}{\partial \phi \partial q_0}$ *is increasing in* ϕ *for* $\phi < \tilde{\phi}$.

Proposition 1. *If prior ideology and content are information substitutes and Assumption 2 is satisfied, the optimal content-providing contract has the screening property.*

1. *The ex-post indifferent type of reader takes the most credible content of either stance,* $q_1^*(\tilde{\phi}) = 1$ *and* $q_0^*(\tilde{\phi}) = 0$.

2. *A reader of ideology* $\phi > \tilde{\phi}$ *takes the content supporting the new regime with declining credibility in* ϕ, $q_1^*(\phi) \in [\tilde{q}, 1]$ *with* $\frac{dq_1^*(\phi)}{d\phi} \leq 0$.

3. *A reader of ideology* $\phi < \tilde{\phi}$ *takes the content supporting the status quo with declining credibility in* $1-\phi$, $q_0^*(\phi) \in [0, \tilde{q}]$ *with* $\frac{dq_0^*(\phi)}{d\phi} \leq 0$.

4. *A reader of ideology closer to the ex-post indifferent type pays more for a more credible content,* $\frac{dt_1^*(\phi)}{d\phi} \leq 0$ *and* $\frac{dt_0^*(\phi)}{d\phi} \geq 0$.

Proof. Lemma 1 to Lemma 3, and Appendix A4. □

The ex-post indifferent type of reader resembles the "efficient type" in standard contracting. The content provider induces him to take the most credible content at the highest transfer. Given information substitutability, a reader with a stronger prior ideology towards the new regime (respectively status quo) than the ex-post indifferent type has a lower marginal value on the credibility of content supporting the new regime (respectively status quo), as well as a lower willingness to pay for the more credible content. It is within-stance incentive compatible for the reader of a stronger ideology not to take the more credible content of the same stance and vice versa, if the content-providing contract exhibits declining credibility and transfer as the reader's prior ideology being farther from the ex-post indifferent type. This contract is also across-stance incentive compatible[11] for the types of readers who are induced to take the pro-new-regime content not to take the pro-status-quo content, and vice versa. Intuitively, a reader enjoys a higher value of content of the opposite stance only if such content is highly credible. With declining credibility and transfer as the ideology is farther from the ex-post indifferent type, this is as if the reader mimics a type closer

[11] This is shown in Lemma A1 in Appendix A4.

to the ex-post indifferent, who has a higher willingness to pay for the more credible content. Such deviation must not be payoff improving for the reader.

Proposition 1 does not rule out the possibility of pooling for the extreme types of readers. Depending on how the reader updates his belief from the content (e.g., Bayesian updating in the next section), it can be optimal to provide the commonly recognized neutral content for free to the reader with a sufficiently strong prior ideology over either stance. Content providers such as journals and online streaming provide both free content and extended content at a pricing plan. The screening property in Proposition 1 provides a possible explanation for such menu of contents.

If content and ideology are information complements, the optimal contract is characterized in Proposition 2.

Proposition 2. *If prior ideology and content are information complements, the optimal content-providing contract has the bang-bang property.*

1. *A reader of relatively extreme ideology* $\phi > \overline{\phi}$ *and* $\phi < \underline{\phi}$, $0 < \underline{\phi} < \overline{\phi} < 1$, *take the commonly recognized neutral content for free.*

2. *A reader of ideology* $\phi \in [\tilde{\phi}, \overline{\phi}]$ *takes the fully credible content supporting the new regime at a fixed price,* $q_1^*(\phi) = 1$ *at* $t_1^*(\phi) = t_1^*(\overline{\phi})$ *such that* $u(\overline{\phi}) = \max\{\overline{\phi}, 1-\overline{\phi}\}$.

3. *A reader of ideology* $\phi \in [\underline{\phi}, \tilde{\phi}]$ *takes the fully credible content supporting the status quo at a fixed price,* $q_0^*(\phi) = 0$ *at* $t_0^*(\phi) = t_0^*(\underline{\phi})$ *such that* $u(\underline{\phi}) = \max\{\underline{\phi}, 1-\underline{\phi}\}$.

Proof. Lemma 1 to Lemma 3, and Appendix A5. □

Given information complementarity, a reader with a stronger ideology has a larger marginal value on the credibility of content supporting a given stance, but he is willing to pay less for the content. With the presence of such countervailing incentives, the optimal contract includes fully credible content of opposite stances, each at a fixed price. If the provider induces all types of readers to take the fully credible content, it is individually rational only at zero transfer. The provider can be better off providing commonly recognized neutral content for free to the reader of relatively extreme ideology, who has a lower willingness to pay for the fully credible content. This allows the content provider to raise the transfer for fully credible content without violating incentive compatibility and individual rationality.

4 Content Provision with Bayesian Belief

To characterize a tractable content-providing contract, suppose that the reader has Bayesian belief, $\sigma(\phi, q) = \frac{\phi \cdot q}{\phi \cdot q + (1-\phi)\cdot(1-q)}$. With Bayesian belief, the content and prior ideology are information substitutes, and the commonly recognized neutral content is $\tilde{q} = \frac{1}{2}$. The optimal contract with Bayesian readers is characterized in Proposition 3, given Assumption 3.

Assumption 3. *Inverse hazard rate is monotone:* $\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}$ *is increasing in* ϕ *for* $\phi > \tilde{\phi}$ *and* $\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}$ *is decreasing in* ϕ *for* $\phi < \tilde{\phi}$.

Proposition 3. *Suppose the readers have Bayesian belief with Assumption 3 satisfied. The optimal content-providing contract has the following screening property, with* $0 < \overline{\phi}_0 < \tilde{\phi}_0 < \tilde{\phi} = \frac{1}{2} < \tilde{\phi}_1 < \overline{\phi}_1 < 1$.

1. *A reader of relatively neutral ideology* $\phi \in [\tilde{\phi}, \tilde{\phi}_1]$ *or* $\phi \in [\tilde{\phi}_0, \tilde{\phi}]$ *takes fully credible content of either stance,* $q_1^*(\phi) = 1$ *or* $q_0^*(\phi) = 0$ *respectively.*

2. *A reader of sufficiently extreme ideology* $\phi > \overline{\phi}_1$ *or* $\phi < \overline{\phi}_0$ *takes the commonly recognized neutral content for free.*

3. *A reader of ideology* $\phi \in (\tilde{\phi}_1, \overline{\phi}_1)$ *takes the content supporting the new regime with declining credibility in* ϕ, $q_1^*(\phi) \in (\tilde{q}, 1)$ *with* $\frac{dq_1^*(\phi)}{d\phi} < 0$.

4. *A reader of ideology* $\phi \in (\overline{\phi}_0, \tilde{\phi}_0)$ *takes the content supporting the status quo with declining credibility in* $1 - \phi$, $q_0^*(\phi) \in (0, \tilde{q})$ *with* $\frac{dq_0^*(\phi)}{d\phi} < 0$.

Proof. Lemma 1 to Lemma 3, and Appendix A6. □

The optimal content-providing contract is symmetric, with the ex-post indifferent type being the ex-ante neutral type, $\tilde{\phi} = \frac{1}{2}$. For a reader of a sufficiently neutral ideology, fully credible content of the same stance is highly valuable. The content provider finds it optimal to provide fully credible content to these types of readers, reducing the credibility of content to the readers of relatively stronger ideology so that she is able to charge a higher transfer for more credible content. Bayesian belief has the property of increasing information substitutability, i.e., the marginal value of content diminishes at a larger magnitude for a stronger prior ideology. Assumption 3 on the monotone hazard rate is sufficient for the optimality of declining credibility in stronger ideology. For a reader of a sufficiently extreme ideology, even highly credible content is of little net value. The content provider finds it optimal to provide the

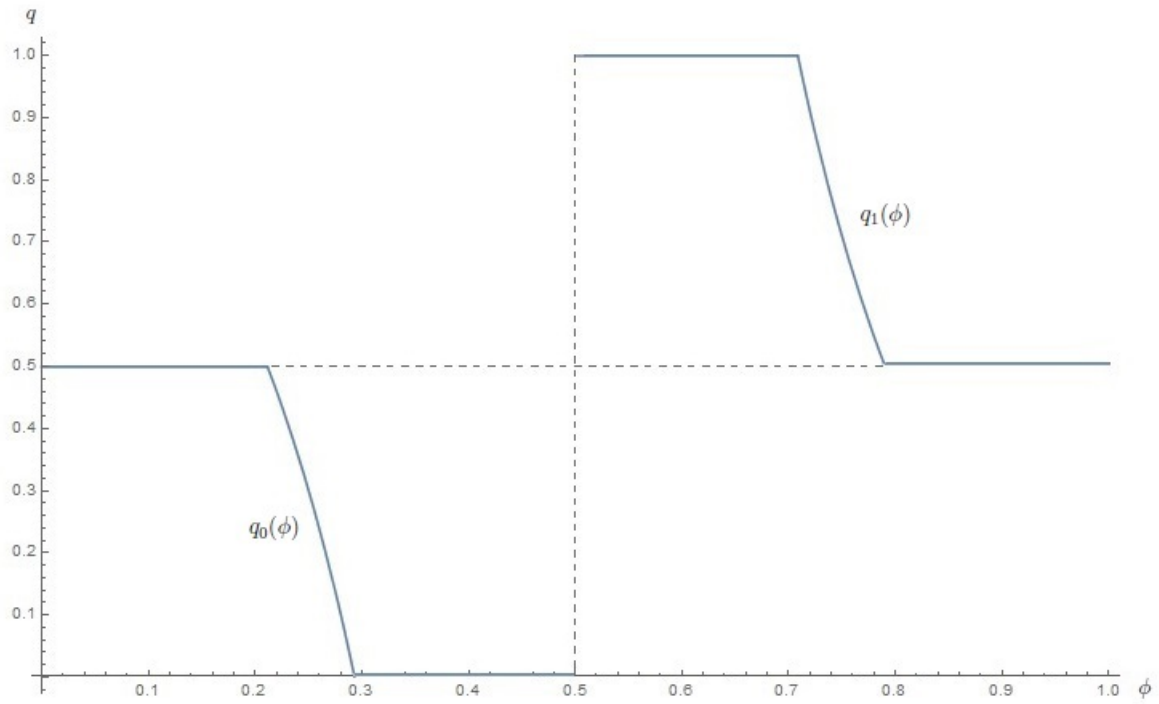

Figure 2: Optimal Content
The optimal content is based on Bayesian belief and uniformly distributed prior ideology between zero and one.

commonly recognized neutral content at zero transfer to these types of readers, which is incentive compatible for the relatively neutral types of readers by their respective individual rationality. The contracted content is illustrated with uniformly distributed ideology in Figure 1.

Freemium. The optimal contract in Proposition 3 (and in Proposition 2 as well) exhibits the property of freemium: a menu consists of basic (commonly recognized neutral) content for free and some options of premium content at a price increasing in credibility. Freemium is also found optimal in some studies of the non-informational content provision in digital platforms, e.g., Sato (2019) on the optimality of freemium in a two-sided platform with advertisement, and Halmenschlager and Waelbroeck (2014) on the optimality of freemium to fight against piracy in music streaming platforms. Sato (2019) is closer to this paper in terms of screening, where consumers are segmented by their willingness to interact with (to tolerate) the advertisers. In the current paper, the screening device is the credibility of informational content, and readers are segmented by their prior ideology. Even with the inherent difference between informational and non-informational content, the former having an additional dimension of stance, the optimality of freemium is robust.

Formation of posterior belief. Following the optimal content-providing contract in Proposition 3, the formation of the reader's posterior belief is summarized in the following corollary.

Corollary 1. *The reader's posterior belief exhibits polarization across stances but convergence within each stance.*

Under the symmetric content-providing contract, a reader of relatively neutral ideology is induced to take highly credible content of the same stance. After reading the full content, he is more asserted about his prior stance. On the other hand, a reader of a sufficiently extreme ideology does not update his belief after reading the neutral content. Readers of the same prior stance have closer updated beliefs, while readers of opposite prior stances become more diverged in their updated beliefs. This corollary on polarization across stances echoes the literature on ex-post belief polarization mentioned in the literature review. It, along with convergence within stance, also echoes the literature on media bias and ideological segregation.[12] The

[12]Please refer to the seminal work of Gentzkow and Shapiro (2006), Gentzkow and Shapiro (2011) on ideological segregation online and offline, Mullainathan and Shleifer (2005) on media competition

difference is that the corollary does not result from the readers choosing different sources of information but from a single content provider screening the reader's prior ideology.

Optimal contract in practice. One way to practically implement the key characteristics of the optimal contract is to offer some basic content for free to everyone and options for in-depth analysis at a price. This in-depth analysis can be in the form of paid-members-only articles/videos or books/documentaries with more details of the same issue as gifts to the paid members. From a quantity perspective, social issues are usually so complicated that they cannot be well-explained in a single article. Content on a single issue is made more credible as a series of articles. The provider can implement the optimal contract by offering limited access to only a few articles for free and more articles in the series at a higher price for readers who demand more credible information on the issue.

5 Conclusion

I characterize the optimal provision of informative content through a menu of options that screens the content reader's prior ideology and shapes his posterior belief. Screening relies on distortion of content credibility, which exhibits the tradeoff between information rent and assertion. The content provider is able to extract a higher information rent from a reader with a weaker prior ideology by inducing a reader with a stronger prior ideology of the same stance to take less credible content. This is at the expense of the reader's assertion of the real state of the world.

The equilibrium distortion depends on whether the reader regards his prior ideology and the content as information substitutes or information complements. If the ideology and content are information substitutes, the optimal content-providing contract has the screening property: readers with stronger ideology are induced to take less credible content at lower prices, with the most extreme readers induced to take the commonly recognized neutral content for free. If the ideology and content are information complements, the optimal content-providing contract has the bang-bang property: readers with extreme ideology are induced to take the commonly recognized neutral content for free, while readers of non-extreme ideology are induced to take fully credible content of either stance at a fixed price.

through extreme slanting, and Bakshy, Messing, and Adamic (2015) on diverse choices of news and opinions on social media.

I derive a tractable solution to the optimal content-providing contract with Bayesian belief, given which a reader regards his ideology and the content as information substitutes. The optimal content-providing contract exhibits freemium. Readers of relatively neutral ideology are induced to take more credible content at higher prices, while readers of sufficiently extreme ideology are induced to take the commonly recognized neutral content for free. As a corollary, the optimal content-providing contract sheds light on belief polarization and belief congruence. The readers are weakly more asserted about their initial stance after receiving the full content. Readers of the same ex-ante stance have congruent posterior beliefs after receiving the full content. In contrast, readers of opposite ex-ante stances have polarized posterior beliefs after receiving the full content.

The analysis is ready for extension in a couple of directions. I have focused on static screening in the current paper. A dynamic screening model is more naturally related to the real-life scenario. With multiple periods, each endowed with an "issue" and the reader's prior ideology regarding such issue, the prediction of the current paper is robust if the issues and the reader's prior ideology regarding each issue are independent across time. A more interesting scenario to study is where the reader's ideology on the issues is correlated across time. The content provided in each period then screens the correlated per-period ideologies and shapes the future ideologies. This requires a much more advanced analysis toolkit and is left for future research. In addition, there is a single content provider in the current paper. In reality, multiple informative content providers can compete with each other with similar topics, or they can complement each other with various topics. It is intriguing to study how ideological screening interacts with the competition or complementary relationships among multiple content providers.

References

[1] Babaioff, Moshe, Robert Kleinberg, and Renato Paes Leme (2012), "Optimal Mechanisms for Selling Information," ACM 978-1-4503-1415-2/12/06, 92–109

[2] Bakshy, Eytan, Solomon Messing, and Lada Adamic (2015), "Exposure to Ideologically Diverse News and Opinion on Facebook," *Science* 348(6239), 1130–1132

[3] Benôit, Jean-Pierre and Juan Dubra (2019), " Apparent Bias: What Does Attitude Polarization Show?" *International Economic Review* 60(4), 1675–1703

[4] Bergemann, Dirk and Alessandro Bonatti (2015), "Selling Cookies," *American Economic Journal: Microeconomics* 7(3), 259–294

[5] Bergemann, Dirk, Alessandro Bonatti, and Alex Smolin (2018), "The Design and Price of Information," *American Economic Review* 108(1), 1–48

[6] Bergemann, Dirk and Stephen Morris (2019), "Information Design: A Unified Perspective," *Journal of Economic Literature* 57(1), 44–95

[7] Che, Yeon-Koo and Navin Kartik (2009), "Opinions as Incentives," *Journal of Political Economy* 117(5), 815–860

[8] Chen, Yiling, Haifeng Xu, and Shuran Zheng (2020), "Selling Information Through Consulting," SIAM, 2412–2431

[9] Eliaz, Kfir and Ran Spiegler (2006), "Contracting with Diversely Naive Agents," *Review of Economic Studies* 73, 689–714

[10] Eliaz, Kfir and Ran Spiegler (2008), "Consumer Optimism and Price Discrimination," *Theoretical Economics* 3, 459–497

[11] Eső, Péter and Balázs Szentes (2007), "The Price of Advice," *RAND Journal of Economics* 38(4), 863–880

[12] Gentzkow, Matthew and Jesse Shapiro (2006), "Media Bias and Reputation," *Journal of Political Economy* 114(2), 280–316

[13] Gentzkow, Matthew and Jesse Shapiro (2011), "Ideological Segregation Online and Offline," *Quarterly Journal of Economics* 126, 1799–1839

[14] Gentzkow, Matthew, Michael B. Wong, and Allen T. Zhang (2021), "Ideological Bias and Trust in Information Sources," working paper (https://web.stanford.edu/~gentzkow/research/trust.pdf)

[15] Grubb, Michael (2009), "Selling to Overconfident Consumers," *American Economic Review* 99(5), 1770–1807

[16] Halmenschlager, Christine and Patrick Waelbroeck (2014), "Fighting Free with Free: Freemium vs. Piracy," available at SSRN (https://dx.doi.org/10.2139/ssrn.2475641)

[17] Kamenica, Emir and Matthew Gentzkow (2011), "Bayesian Persuasion," *American Economic Review* 101 (6), 2590–2615

[18] Kartik, Navin, Frances Xu Lee, and Wing Suen (2021), "Information Validates the Prior: A Theorem on Bayesian Updating and Applications," *American Economic Review: Insights* 3(2), 165–182

[19] Kastl, Jakub, Marco Pagnozzi, and Salvatore Piccolo (2018), "Selling Information to Competitive Firms," *Rand Journal of Economics*, 49(1), 254–282

[20] Kolotilin, Anton, Tymofiy Mylovanov, Andriy Zapechelnyuk, and Ming Li (2017), "Persuasion of a Privately Informed Receiver," *Econometrica* 85(6), 1949–1964

[21] Krishna, Vijay and John Morgan (2008), "Contracting for Information under Imperfect Commitment," *RAND Journal of Economics* 39(4), 905–925

[22] Liu, Shuze, Weiran Shen, and Haifeng Xu (2021), "Optimal Pricing of Information," Proceedings of the 22nd ACM Conference on Economics and Computation, 693

[23] Min, Daehong (2021), "Screening for Experiments," working paper (http://www.daehongmin.com/s/SFE_mainRF_3rd.pdf)

[24] Mitchell, Matthew (2021), "Free Ad(vice): Internet Influencers and Disclosure Regulation," *RAND Journal of Economics* 52(1), 3–21

[25] Mullainathan, Sendhil and Andrei Shleifer (2005), "The Market for News," *American Economic Review* 95(4), 1031–1053

[26] Sandroni, Alvaro and Francesco Squintani (2007), "Overconfidence, Insurance, and Paternalism," *American Economic Review* 97(5), 1994–2004

[27] Sato, Susumu (2019), "Freemium as Optimal Menu Pricing," *International Journal of Industrial Organization* 63, 480–510

[28] Suen, Wing (2004), "The Self-Perpetuation of Biased Beliefs," *Economic Journal* 114 (April), 377–396

[29] Taylor, Curtis (2004), "Consumer Privacy and the Market for Customer Information," *Rand Journal of Economics* 35(4), 631–650

[30] Yildiz, Muhamet (2003), "Bargaining without a Common Prior – An Immediate Agreement Theorem," *Econometrica* 71(3), 793–811

A Appendix

A.1 Proof of Lemma 1

Incentive compatible content-providing contract is such that $\phi \in \arg\max_{\hat{\phi}}\{\sigma(\phi, q(\hat{\phi})), 1-\sigma(\phi, q(\hat{\phi}))\} - t(\hat{\phi})$ for all ϕ. For the sake of clarity, denote the options in the contract that induce updated beliefs of $\sigma(\phi, q(\phi)) > 1-\sigma(\phi, q(\phi))$ given truthful revelation as $\{(q_1(\phi), t_1(\phi))\}$ and those that induce updated beliefs of $\sigma(\phi, q(\phi)) < 1-\sigma(\phi, q(\phi))$ given truthful revelation as $\{(q_0(\phi), t_0(\phi))\}$.

The reader of ideological type ϕ induced to take $\{(q_1(\phi), t_1(\phi))\}$ has incentive to truthfully reveals his prior ideology if the following first-order and second-order conditions are satisfied at $\hat{\phi} = \phi$, $\frac{\partial\sigma(\phi,q_1)}{\partial q_1} \cdot q_1'(\hat{\phi}) - t_1'(\hat{\phi}) = 0$ and $\frac{\partial^2\sigma(\phi,q_1)}{\partial q_1^2} \cdot \left(q_1'(\hat{\phi})\right)^2 + \frac{\partial\sigma(\phi,q_1)}{\partial q_1} \cdot q_1''(\hat{\phi}) - t_1''(\hat{\phi}) \leq 0$. At $\hat{\phi} = \phi$, the first-order condition holds with identity, first-order derivative of which with respect to ϕ yields $\frac{\partial^2\sigma(\phi,q_1)}{\partial q_1^2} \cdot (q_1'(\phi))^2 + \frac{\partial\sigma(\phi,q_1)}{\partial q_1} \cdot q_1''(\phi) - t_1''(\hat{\phi}) + \frac{\partial^2\sigma(\phi,q_1)}{\partial q_1\partial\phi} \cdot q_1'(\phi) = 0$. The second-order condition holds if $\frac{\partial^2\sigma(\phi,q_1)}{\partial q_1\partial\phi} \cdot q_1'(\phi) \geq 0$. If the prior belief and content are information substitutes in the sense that $\frac{\partial^2\sigma(\phi,q_1)}{\partial q_1\partial\phi} < 0$, incentive compatibility requires $q_1'(\phi) \leq 0$ and $t_1'(\phi) \leq 0$; if the prior belief and content are information complements in the sense that $\frac{\partial^2\sigma(\phi,q_1)}{\partial q_1\partial\phi} > 0$, incentive compatibility requires $q_1'(\phi) \geq 0$ and $t_1'(\phi) \geq 0$.

The reader of ideological type ϕ induced to take $\{(q_0(\phi), t_0(\phi))\}$ has incentive to truthfully reveals his prior ideology if the following first-order and second-order conditions are satisfied at $\hat{\phi} = \phi$, $\frac{\partial(1-\sigma(\phi,q_0))}{\partial q_0} \cdot q_0'(\hat{\phi}) - t_0'(\hat{\phi}) = 0$ and $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial q_0^2} \cdot \left(q_0'(\hat{\phi})\right)^2 + \frac{\partial(1-\sigma(\phi,q_0))}{\partial q_0} \cdot q_0''(\hat{\phi}) - t_0''(\hat{\phi}) \leq 0$. At $\hat{\phi} = \phi$, the first-order condition holds with identity, first-order derivative of which with respect to ϕ yields $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial q_0^2} \cdot (q_0'(\phi))^2 + \frac{\partial(1-\sigma(\phi,q_0))}{\partial q_0} \cdot q_0''(\phi) - t_0''(\phi) + \frac{\partial^2(1-\sigma(\phi,q_0))}{\partial q_0\partial\phi} \cdot q_0'(\phi) = 0$. The second-order condition holds if $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial q_0\partial\phi} \cdot q_0'(\phi) \geq 0$. If the prior belief and content are information substitutes in the sense that $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial q_0\partial\phi} < 0$, incentive compatibility requires $q_0'(\phi) \leq 0$ and $t_0'(\phi) \geq 0$; if the prior belief and content are information complements in the sense that $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial q_0\partial\phi} > 0$, incentive compatibility requires $q_0'(\phi) \geq 0$ and $t_0'(\phi) \leq 0$.

A.2 Proof of Lemma 2

Given incentive compatibility, the content-providing contract is individually rational if $u(\phi) \geq \max\{\phi, 1-\phi\}$ for all ϕ. For clarity, denote the reader's payoff implemented by $\{(q_1(\phi), t_1(\phi))\}$ as $u_1(\phi)$ and that implemented by $\{(q_0(\phi), t_0(\phi))\}$ as $u_0(\phi)$. By the envelope theorem of the reader's truthful revelation, $u_1'(\phi) = \frac{\partial\sigma(\phi,q_1(\phi))}{\partial\phi} > 0$ and

$u_0'(\phi) = \frac{\partial(1-\sigma(\phi,q_0(\phi)))}{\partial\phi} < 0$.

If $u_1'(\phi) > 1$ for some sufficiently large $\phi > \frac{1}{2}$, $u_1(\phi) - \phi$ is increasing for these types. Individual rationality is binding at $\phi = \phi' < 1$ and slacking for $\phi > \phi'$. Payoff $u_1(\phi) > 1$ is implemented by $t_1(1) < 0$. This is not optimal for the content provider. The content provider can be better off by offering the commonly recognized neutral content $\tilde{q}$ with zero transfer to the reader of type $\phi = 1$ instead, which is individually rational for type $\phi = 1$ and incentive compatible for other types given their respective individual rationality. If the reader with sufficiently large ϕ is induced to take $\{(q_1(\phi), t_1(\phi))\}$ with $u_1'(\phi) < 1$ or induced to take $\{(q_0(\phi), t_0(\phi))\}$, $u_1(\phi) - \phi$ or $u_0(\phi) - \phi$ is diminishing for these types. Individual rationality is binding for at least the reader with $\phi = 1$.

If $u_0'(\phi) < -1$ for some sufficiently small $\phi < \frac{1}{2}$, $u_0(\phi) - (1 - \phi)$ is diminishing for these types. Individual rationality is binding at $\phi = \phi' > 0$ and slacking for $\phi = 0$. Payoff $u_0(0) > 1$ is implemented by $t_0(0) < 0$. This is not optimal for the content provider as she can be better off offering the commonly recognized neutral content $\tilde{q}$ with zero transfer to the reader of type $\phi = 0$ instead, which is individually rational for type $\phi = 0$ and incentive compatible for other types given their respective individual rationality. If the reader with sufficiently sufficiently small ϕ is induced to take $\{(q_0(\phi), t_0(\phi))\}$ with $u_0'(\phi) > -1$ or induced to take $\{(q_1(\phi),\ t_1(\phi))\}$, $u_0(\phi) - (1-\phi)$ or $u_1(\phi) - (1 - \phi)$ is increasing for these types. Individual rationality is binding for at least the reader with $\phi = 0$.

A.3 Proof of Lemma 3

By the envelope theorem of the reader's truthful revelation, $u_1'(\phi) = \frac{\partial\sigma(\phi,q_1(\phi))}{\partial\phi} > 0$ and $u_0'(\phi) = \frac{\partial(1-\sigma(\phi,q_0(\phi)))}{\partial\phi} < 0$. By continuity, the contract either induces the reader of types $\phi > \tilde{\phi}$ to take $\{(q_1(\phi), t_1(\phi))\}$ and the reader of types $\phi < \tilde{\phi}$ to take $\{(q_0(\phi), t_0(\phi))\}$, or induces the reader of types $\phi > \tilde{\phi}$ to take $\{(q_0(\phi), t_0(\phi))\}$ and the reader of types $\phi < \tilde{\phi}$ to take $\{(q_1(\phi), t_1(\phi))\}$. Suppose that the reader of types $\phi > \tilde{\phi}$ is induced to take $\{(q_0(\phi),\ t_0(\phi))\}$ and the reader of types $\phi < \tilde{\phi}$ is induced to take $\{(q_1(\phi), t_1(\phi))\}$. The implemented payoffs are $u_1(\phi) = u_1(0) + \int_0^{\phi} \frac{\partial\sigma(x,q_1(x))}{\partial x} dx$ and $u_0(\phi) = u_0(1) - \int_{\phi}^{1} \frac{\partial(1-\sigma(x,q_0(x)))}{\partial x} dx$. By binding individual rationality at $\phi = 1$ and at $\phi = 0$, $u_1(0) = 1$ and $u_0(1) = 1$. These payoffs can be implemented only by $t_0(\phi) < 0$ and $t_1(\phi) < 0$. The content provider can be better off providing the commonly recognized neutral content $\tilde{q}$ at zero transfer to the reader.

Given Assumption 1-2, for any $\phi > \tilde{\phi}$, the content of credibility $q_1(\phi) < \tilde{q}$ imple-

ments the posterior belief $\sigma(\phi, q_1(\phi)) < \phi \leq \max\{\phi, 1-\phi\}$. The reader is willing to accept this contract only if $t_1(\phi) < 0$. For any $\phi < \tilde{\phi}$, the content of credibility $q_0(\phi) > \tilde{q}$ implements the posterior belief $1 - \sigma(\phi, q_0(\phi)) < 1 - \phi \leq \max\{\phi, 1-\phi\}$. The reader is willing to accept this contract only if $t_0(\phi) < 0$. There is an alternative contract in which the commonly recognized neutral content $\tilde{q}$ at zero transfer replaces $q_1(\phi) < \tilde{q}$ at $t_1(\phi) < 0$ and $q_0(\phi) > \tilde{q}$ at $t_0(\phi) < 0$, other parts of the contract remaining the same. This alternative contract is incentive compatible for the types that are induced to take $\tilde{q}$ by Lemma 1 and incentive compatible for the types that are induced to take $q_1(\phi) > \tilde{q}$ and $q_0(\phi) < \tilde{q}$ given their respective individual rationality. The content provider is better off proposing the alternative contract instead.

A.4 Proof of Proposition 1

By Lemma 1 to Lemma 3, the reader's implemented payoff has $u_1(\phi) = u_1(1) - \int_\phi^1 \frac{\partial \sigma(x, q_1(x))}{\partial x} dx = 1 - \int_\phi^1 \frac{\partial \sigma(x, q_1(x))}{\partial x} dx$ and $u_0(\phi) = u_0(0) + \int_0^\phi \frac{\partial (1 - \sigma(x, q_0(x)))}{\partial x} dx = 1 + \int_0^\phi \frac{\partial (1 - \sigma(x, q_0(x)))}{\partial x} dx$. By definition of ex-post indifference, $u_1(\tilde{\phi}) = u_0(\tilde{\phi})$ implies $\int_{\tilde{\phi}}^1 \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} d\phi + \int_0^{\tilde{\phi}} \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} d\phi = 0$. The content provider's contracting problem is reduced to

$$\max_{q(\phi), \tilde{\phi}} \int_0^1 \mathbf{1}_{\phi \geq \tilde{\phi}} \cdot (\sigma(\phi, q_1(\phi)) - u_1(\phi)) + \mathbf{1}_{\phi \leq \tilde{\phi}} \cdot (1 - \sigma(\phi, q_0(\phi)) - u_0(\phi)) \, dF(\phi)$$

subject to $q_1(\phi) \in [\tilde{q}, 1]$ and $q_0(\phi) \in [0, \tilde{q}]$ by Lemma 3, and $q_i'(\phi) \leq 0$ for $i = 0, 1$ by Lemma 1, where $u_1(\phi) = 1 - \int_\phi^1 \frac{\partial \sigma(x, q_1(x))}{\partial x} dx$ and $u_0(\phi) = 1 + \int_0^\phi \frac{\partial (1 - \sigma(x, q_0(x)))}{\partial x} dx$. Indicator functions $\mathbf{1}_{\phi \geq \tilde{\phi}} = 1$ or $\mathbf{1}_{\phi \leq \tilde{\phi}} = 1$ if $\phi \geq \tilde{\phi}$ or $\phi \leq \tilde{\phi}$ respectively, zero otherwise. Applying integration by parts, $\int_{\tilde{\phi}}^1 \left(\int_\phi^1 \frac{\partial \sigma(x, q_1(x))}{\partial x} dx \right) dF(\phi) = -\int_{\tilde{\phi}}^1 \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} d\phi \cdot F(\tilde{\phi}) + \int_{\tilde{\phi}}^1 F(\phi) \cdot \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} d\phi = \int_{\tilde{\phi}}^1 \frac{F(\phi) - F(\tilde{\phi})}{f(\phi)} \cdot \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} dF(\phi)$ and $\int_0^{\tilde{\phi}} \left(\int_0^\phi \frac{\partial (1 - \sigma(x, q_0(x)))}{\partial x} dx \right) dF(\phi) = \int_0^{\tilde{\phi}} \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} d\phi \cdot F(\tilde{\phi}) - \int_0^{\tilde{\phi}} F(\phi) \cdot \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} d\phi = \int_0^{\tilde{\phi}} \frac{F(\tilde{\phi}) - F(\phi)}{f(\phi)} \cdot \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} dF(\phi)$. The contracting problem is further reduced to

$$\max_{q(\phi), \tilde{\phi}} \int_0^1 \mathbf{1}_{\phi \geq \tilde{\phi}} \cdot \left(\sigma(\phi, q_1(\phi)) + \frac{F(\phi) - F(\tilde{\phi})}{f(\phi)} \cdot \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} \right) + \mathbf{1}_{\phi \leq \tilde{\phi}} \cdot \left(1 - \sigma(\phi, q_0(\phi)) - \frac{F(\tilde{\phi}) - F(\phi)}{f(\phi)} \cdot \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} \right) dF(\phi)$$

subject to $q_1(\phi) \in [\tilde{q}, 1]$, $q_0(\phi) \in [0, \tilde{q}]$, and $q_i'(\phi) \leq 0$ for $i = 0, 1$.

The pointwise optimality conditions regarding $q_1(\phi)$ are such that $q_1(\phi) \in (\tilde{q}, 1)$

solves $\frac{\partial\sigma(\phi,q_1)}{\partial q_1}+\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}\cdot\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1}=0$, $q_1(\phi)=1$ for $\frac{\partial\sigma(\phi,q_1)}{\partial q_1}+\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}\cdot\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1}>0$ at $q_1=1$, and $q_1(\phi)=\tilde{q}$ for $\frac{\partial\sigma(\phi,q_1)}{\partial q_1}+\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}\cdot\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1}<0$ at $q_1=\tilde{q}$. With $\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1}<0$, $q_1'(\phi)<0$ if $\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}\cdot\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1}$ is decreasing in ϕ (or its absolute value is increasing in ϕ). The pointwise optimality conditions regarding $q_0(\phi)$ are such that $q_0(\phi)\in(0,\tilde{q})$ solves $\frac{\partial(1-\sigma(\phi,q_0))}{\partial q_0}-\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}\cdot\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0}=0$, $q_0(\phi)=0$ for $\frac{\partial(1-\sigma(\phi,q_0))}{\partial q_0}-\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}\cdot\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0}<0$ at $q_0=0$, and $q_0(\phi)=\tilde{q}$ for $\frac{\partial(1-\sigma(\phi,q_0))}{\partial q_0}-\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}\cdot\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0}>0$ at $q_0=\tilde{q}$. With $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0}<0$, $q_0'(\phi)<0$ if $\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}\cdot\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0}$ is increasing in ϕ (or its absolute value is decreasing in ϕ). Specifically, for the ex-post indifferent type $\tilde{\phi}$, he is made indifferent between the fully credible content of opposite stances $q_1(\tilde{\phi})=1$ and $q_0(\tilde{\phi})=0$. The optimal choice of the ex-post indifferent type of reader $\tilde{\phi}$ is such that $\int_{\tilde{\phi}}^1\left(-\frac{f(\tilde{\phi})}{f(\phi)}\cdot\frac{\partial\sigma(\phi,q_1(\phi))}{\partial\phi}\right)dF(\phi)+\int_0^{\tilde{\phi}}\left(-\frac{f(\tilde{\phi})}{f(\phi)}\cdot\frac{\partial(1-\sigma(\phi,q_0(\phi)))}{\partial\phi}\right)dF(\phi)-\sigma(\tilde{\phi},q_1(\tilde{\phi}))+1-\sigma(\tilde{\phi},q_0(\tilde{\phi}))=0$. This equality holds at $\sigma(\tilde{\phi},q_1(\tilde{\phi}))=1-\sigma(\tilde{\phi},q_0(\tilde{\phi}))$ as $\int_{\tilde{\phi}}^1\frac{\partial\sigma(\phi,q_1(\phi))}{\partial\phi}d\phi+\int_0^{\tilde{\phi}}\frac{\partial(1-\sigma(\phi,q_0(\phi)))}{\partial\phi}d\phi=0$ implied by definition of ex-post indifference.

What is left to check is whether the reader has an incentive to take an option that induces a different stance from that the content provider intends to implement, i.e., incentive compatibility across stances.

Lemma A1. *Given the above contract, the reader with $\phi>\tilde{\phi}$ has no incentive to take any option in $\{(q_0(\phi),t_0(\phi))\}$ that flips his stance, and the reader with $\phi<\tilde{\phi}$ has no incentive to take any option in $\{(q_1(\phi),t_1(\phi))\}$ that flips his stance.*

Proof. We first argue that the reader with $\phi>\tilde{\phi}$ has no incentive to take the option $(q_0(\phi'),t_0(\phi'))$ that implements the same ex-post value of content, i.e. $q_0(\phi')$ such that $\sigma(\phi,q_1(\phi))=1-\sigma(\phi,q_0(\phi'))$. Given $\frac{dq_i(\phi)}{d\phi}<0$ for $i=0,1$, ϕ is a "more extreme" type than ϕ' relative to $\tilde{\phi}$. Given $\frac{dt_1(\phi)}{d\partial\phi}<0$ and $\frac{dt_0(\phi)}{d\phi}>0$, the type-$\phi$ reader has no incentive to mimic the type-ϕ'reader, anticipating the same ex-post value of content at a higher transfer. By symmetric argument, the reader with $\phi<\tilde{\phi}$ has no incentive to take the option $(q_1(\phi'),t_1(\phi'))$ that implements the same ex-post value of content, i.e. $q_1(\phi')$ such that $1-\sigma(\phi,q_0(\phi))=\sigma(\phi,q_1(\phi'))$. Next we argue that the reader with $\phi>\tilde{\phi}$ has no incentive to take the option $(q_0(\phi'),t_0(\phi'))$ that implements a different ex-post value of content, i.e. $q_0(\phi')$ such that $\sigma(\phi,q_1(\phi))\neq1-\sigma(\phi,q_0(\phi'))$. By continuity, there is type $\phi''>\tilde{\phi}$ such that the type-ϕ reader expects $\sigma(\phi,q_1(\phi''))=1-\sigma(\phi,q_0(\phi'))$. Given $\frac{dq_i(\phi)}{d\phi}<0$ for $i=0,1$, ϕ'' is a "more extreme" type than ϕ', and given $\frac{dt_1(\phi)}{d\phi}<0$ and $\frac{dt_0(\phi)}{d\phi}>0$, the type-$\phi$ reader expects a lower payoff mimicking the type-ϕ'reader than mimicking the type-ϕ'' reader. By incentive compatibility in Lemma 1, the type-ϕ reader has no incentive to mimic the type-ϕ'' reader. He thus has no incentive to

mimic the type-ϕ' reader, either. By symmetric argument, the reader with $\phi < \tilde{\phi}$ has no incentive to take the option $(q_1(\phi'), t_1(\phi'))$ that implements a different ex-post value of content, i.e. $q_1(\phi')$ such that $1 - \sigma(\phi, q_0(\phi)) \neq \sigma(\phi, q_1(\phi'))$. □

A.5 Proof of Proposition 2

Lemma 1 to Lemma 3 hold for information complements as well, as the proofs do not rely on information substitutability. The content provider's contracting problem is reduced to

$$\max_{q(\phi),\tilde{\phi}} \int_0^1 \mathbf{1}_{\phi \geq \tilde{\phi}} \cdot \left(\sigma(\phi, q_1(\phi)) + \frac{F(\phi) - F(\tilde{\phi})}{f(\phi)} \cdot \frac{\partial \sigma(\phi, q_1(\phi))}{\partial \phi} \right) + \mathbf{1}_{\phi \leq \tilde{\phi}} \cdot \left(1 - \sigma(\phi, q_0(\phi)) - \frac{F(\tilde{\phi}) - F(\phi)}{f(\phi)} \cdot \frac{\partial (1 - \sigma(\phi, q_0(\phi)))}{\partial \phi} \right) dF(\phi)$$

subject to $q_1(\phi) \in [\tilde{q}, 1]$, $q_0(\phi) \in [0, \tilde{q}]$, and $q_i'(\phi) \geq 0$ for $i = 0, 1$. The pointwise first-order derivative with respect to $q_1(\phi)$ has $\frac{\partial \sigma(\phi, q_1)}{\partial q_1} + \frac{F(\phi) - F(\tilde{\phi})}{f(\phi)} \cdot \frac{\partial^2 \sigma(\phi, q_1)}{\partial \phi \partial q_1} > 0$ for all $\phi \geq \tilde{\phi}$ when $\frac{\partial^2 \sigma(\phi, q_1)}{\partial \phi \partial q_1} > 0$, and that with respect to $q_0(\phi)$ has $\frac{\partial (1 - \sigma(\phi, q_0))}{\partial q_0} - \frac{F(\tilde{\phi}) - F(\phi)}{f(\phi)} \cdot \frac{\partial^2 (1 - \sigma(\phi, q_0))}{\partial \phi \partial q_0} < 0$ for all $\phi \leq \tilde{\phi}$ when $\frac{\partial^2 (1 - \sigma(\phi, q_0))}{\partial \phi \partial q_0} > 0$. The content-providing contract that induces full participation of the reader has $q_1(\phi) = 1$ for all $\phi \geq \tilde{\phi}$ and $q_0(\phi) = 0$ for all $\phi \leq \tilde{\phi}$. This contract is individually rational only if $t_1(\phi) = t_0(\phi) = 0$ so that the most extreme type-1 and type-0 readers are willing to accept this contract. The content provider earns zero payoff.

The content provider can be better off proposing an alternative contract: $q_1(\phi) = 1$ at transfer $t_1(\phi) = t_1(\overline{\phi})$ for $\phi \in [\tilde{\phi}, \overline{\phi}]$ and $q_0(\phi) = 0$ at transfer $t_0(\phi) = t_0(\underline{\phi})$ for $\phi \in [\underline{\phi}, \tilde{\phi}]$ that are consistent to the pointwise optimization above with binding individual rationalities for the reader of types $\overline{\phi}$ and $\underline{\phi}$, while $q_1(\phi) = q_0(\phi) = \tilde{q}$ at zero transfer for $\phi > \overline{\phi}$ and $\phi < \underline{\phi}$, with $0 < \underline{\phi} < \tilde{\phi} < \overline{\phi} < 1$. This is as if the provider gives up contracting with the relatively extreme types by offering them the commonly recognized neutral content so that she can profit from the relatively neutral types of readers. This contract is incentive compatible for $\phi \in [\underline{\phi}, \overline{\phi}]$ not to take the neutral content by their respective individual rationality, and it is incentive compatible for $\phi < \underline{\phi}$ and $\phi > \overline{\phi}$ by Lemma 1. It is incentive compatible for $\phi \in [\tilde{\phi}, \overline{\phi}]$ not to take $q_0(\phi) = 0$ as information complementarity implies a higher marginal ex-post value by taking $q_1(\phi) = 1$, vice versa for $\phi \in [\underline{\phi}, \tilde{\phi}]$ not to take $q_1(\phi) = 1$.

A.6 Proof of Proposition 3

Lemma A2. *Bayesian belief satisfies Assumption 1. Given Bayesian belief, the intrinsic ideology and the content are information substitutes, i.e.* $\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1} < 0$ *for* $\sigma(\phi,q_1) > 1-\sigma(\phi,q_1)$ *and* $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0} < 0$ *for* $1-\sigma(\phi,q_0) > \sigma(\phi,q_0)$.

Proof. To see Assumption 1, $\sigma(\phi,q) = \frac{\phi\cdot q}{\phi\cdot q+(1-\phi)\cdot(1-q)}$ given Bayesian belief. There is a commonly recognized neutral content $\tilde{q} = \frac{1}{2}$, such that $\sigma(\phi,\tilde{q}) = \phi$ for all ϕ. The Bayesian belief is increasing in q at any ϕ as $\frac{\partial\sigma(\phi,q)}{\partial q} = \frac{\phi\cdot(1-\phi)}{(\phi\cdot q+(1-\phi)\cdot(1-q))^2} \geq 0$, and it is increasing in ϕ at any q as $\frac{\partial\sigma(\phi,q)}{\partial\phi} = \frac{q\cdot(1-q)}{(\phi\cdot q+(1-\phi)\cdot(1-q))^2} \geq 0$.

With Bayesian belief, $\sigma(\phi,q_1) = \frac{\phi\cdot q_1}{\phi\cdot q_1+(1-\phi)\cdot(1-q_1)} > 1-\sigma(\phi,q_1)$ if $\phi\cdot q_1 > (1-\phi)\cdot(1-q_1)$, which holds if and only if $1-\phi-q_1 < 0$, and $\sigma(\phi,q_0) = \frac{\phi\cdot q_0}{\phi\cdot q_0+(1-\phi)\cdot(1-q_0)} < 1-\sigma(\phi,q_0)$ if $\phi\cdot q_0 < (1-\phi)\cdot(1-q_0)$, which holds if and only if $1-\phi-q_0 > 0$. Conditional on $1-\phi-q_1 < 0$, $\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1} = \frac{1-\phi-q_1}{(\phi\cdot q_1+(1-\phi)\cdot(1-q_1))^3} < 0$; conditional on $1-\phi-q_0 > 0$, $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0} = -\frac{1-\phi-q_0}{(\phi\cdot q_0+(1-\phi)\cdot(1-q_0))^3} < 0$. □

Ideology and content being information substitutes, apply the optimality conditions in Appendix A.4. The optimal content $q_1(\phi) \in (\tilde{q},1)$ solves $\frac{\phi\cdot(1-\phi)}{(\phi\cdot q_1(\phi)+(1-\phi)\cdot(1-q_1(\phi)))^2} + \frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}\cdot\frac{1-\phi-q_1}{(\phi\cdot q_1+(1-\phi)\cdot(1-q_1))^3} = 0$ for $\phi \in (\tilde{\phi}_1,\overline{\phi}_1)$, $q_1(\phi) = 1$ for $\phi \in [\overline{\phi}_1,\tilde{\phi}_1]$ such that $\phi\cdot(1-\phi) - \frac{F(\phi)-F(\tilde{\phi})}{f(\phi)} \geq 0$ with equality at $\tilde{\phi}_1$, and $q_1(\phi) = \tilde{q} = \frac{1}{2}$ for $\phi \geq \overline{\phi}_1$ such that $\phi\cdot(1-\phi) + \frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}\cdot(1-2\cdot\phi) \leq 0$ with equality at $\overline{\phi}_1$. Given $\frac{\partial^2\sigma(\phi,q_1)}{\partial\phi\partial q_1} < 0$ and that $\frac{1-\phi-q_1}{\phi\cdot q_1+(1-\phi)\cdot(1-q_1)} < 0$ is diminishing in ϕ, $q_1'(\phi) < 0$ and $\tilde{\phi} < \tilde{\phi}_1 < \overline{\phi}_1 < 1$ if the distribution of ideology satisfies increasing $\frac{F(\phi)-F(\tilde{\phi})}{f(\phi)}$ in ϕ, à la monotone hazard rate property. The optimal content $q_0(\phi) \in (0,\tilde{q})$ solves $-\frac{\phi\cdot(1-\phi)}{(\phi\cdot q_0(\phi)+(1-\phi)\cdot(1-q_0(\phi)))^2} + \frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}\cdot\frac{1-\phi-q_0(\phi)}{(\phi\cdot q_0(\phi)+(1-\phi)\cdot(1-q_0(\phi)))^3} = 0$ for $\phi \in (\overline{\phi}_0,\tilde{\phi}_0)$, $q_0(\phi) = 0$ for $\phi \in [\tilde{\phi}_0,\tilde{\phi}]$ such that $-\phi\cdot(1-\phi) + \frac{F(\tilde{\phi})-F(\phi)}{f(\phi)} \leq 0$ with equality at $\tilde{\phi}_0$, and $q_0(\phi) = \tilde{q} = \frac{1}{2}$ for $\phi \leq \overline{\phi}_0$ such that $-\phi\cdot(1-\phi) + \frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}\cdot(1-2\cdot\phi) \geq 0$ with equality at $\overline{\phi}_0$. Given $\frac{\partial^2(1-\sigma(\phi,q_0))}{\partial\phi\partial q_0} < 0$ and that $\frac{1-\phi-q_0(\phi)}{\phi\cdot q_0(\phi)+(1-\phi)\cdot(1-q_0(\phi))} > 0$ is diminishing in ϕ, $q_0'(\phi) < 0$ and $0 < \overline{\phi}_0 < \tilde{\phi}_0 < \tilde{\phi}$ if the distribution of ideology satisfies decreasing $\frac{F(\tilde{\phi})-F(\phi)}{f(\phi)}$ in the same fashion as the monotone hazard rate property. Given Bayesian belief, $\sigma(\phi,1) = 1-\sigma(\phi,0) = 1$ for any ϕ, so $\sigma(\tilde{\phi},q_1(\tilde{\phi})) = 1-\sigma(\tilde{\phi},q_0(\tilde{\phi}))$ at any $\tilde{\phi}$, including the symmetric content provision with $\tilde{\phi} = \frac{1}{2}$.