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Media Bias with a Digital Intermediary*

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ABSTRACT

This paper develops a location model of media bias in the market for news with a digital intermediary that uses news items as a loss leader on its platform. In the model, media quality is defined as platforms' ability to increase consumers' utility from interpreting information by better delivering information through news, independent of media bias. The model shows that the digital intermediary minimizes the bias gap between media outlets when its quality is higher than that of media outlets, and maximizes the bias gap or keeps it constant otherwise. If the digital intermediary tolerates a decrease in profit, it can maximize the bias gap or keep it constant even when its quality is higher than that of media outlets. Furthermore, the higher the intermediary's quality relative to media outlets, the lower its media bias adjustment cost.

Keywords: Media bias, Media quality, Digital intermediary, Web portal, Competition, Media plurality

JEL Classifications: L13, L21, L82

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I. INTRODUCTION

In most societies, the consumption of print media has dramatically decreased.[1] In contrast, since the 1990s, digital intermediaries such as Yahoo, Google, Facebook, YouTube, or Naver[2] have rapidly expanded the information content market, including the news market, by blurring the boundary between news information and non-news information in the digital world. As a result, nowadays, most news consumption takes place on the digital intermediaries' platforms.

The price of news content is also determined not in the news market but in the larger digital content market. Most of the traditional news media outlets and digital intermediaries provide the news items to consumers free of charge and acquire revenue from advertisers in the digital online news market, except for very a few media outlets such as *The New York Times* which have worldwide influence and readership. This reality is even more evident in South Korea, the global Internet powerhouse. Thus, this paper discusses whether and how a digital intermediary such as Naver or Google affects media bias when it coexists with media outlets.[3]

In this paper, media bias is defined as the (political) bias of media outlets in the selection of which events are reported and how they are covered, as same as in most previous media bias studies. However, media quality is defined differently from those studies that interpret media quality as the news item's accuracy. In this regard, suppose news items of the same political bias. There are many quality determinants, irrespective of the political bias. For example, video content is easier to understand and more persuasive than text-only content, in general. Examples of media quality include the opportunity to compare the various views of the media outlets, as well as the categorization of news by consumers and their responses to the news (e.g., by

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[1] There has been a dramatic decrease in readership and income of traditional media. In the U.S., the estimated total daily newspaper circulation (print and digital combined) in 2018 was 49% less than in 1998 and even 31% less than in 1940. (Newspaper Facts Sheet. Pew Research Center. July 9, 2019. https://www.journalism.org/fact-sheet/newspapers/)

[2] Naver is the largest digital intermediary in South Korea.

[3] Digital intermediaries can be divided into two groups according to how to provide news items to consumers. Web portal such as Google, Yahoo, and Naver run news pages. In contrast, social networking service as Facebook and online digital content sharing platform as YouTube provide customized news items to users. In this paper, the focus is on the first group.

age, region, or consumption ranking for readers). Not only that, in the digital age, network speed, digital server capacity, or interfaces can also be regarded as high quality in efficiency. These and other characteristics can make up the high quality, as the more persuasive or contextual or accurate expression does, independently of their political bias. Therefore, in the model, media quality is defined as a news provider's ability to reduce the consumers' disutility or increase utility in interpreting information by better delivering information through news. Thus, media quality is independent of both truth and bias.

In the location model of this paper, the different media quality is interpreted as the different transport technology and represented by the transport rate. This idea was originated by Launhardt (1885), whom Ferreira & Thisse (1996) introduced. Ferreira (1998) states that "by distinguishing two qualities, the better product being the lighter and hence the easier to transport." Thus, higher media quality has the effect of reducing the disutility from the distance of bias between media outlets and consumers.

The results of this paper are as follows. In the model, I introduce a digital intermediary that uses news items as a loss leader for its platform into the news market where the qualities of two media outlets are symmetric. There are equilibria of media bias dependent on the relative quality of the digital intermediary to media outlets. When the digital intermediary's quality is higher than those of media outlets, it minimizes the bias gap between media outlets. However, it can control the equilibrium media bias if it tolerates a decrease in profit. When the digital intermediary's quality is not higher than those of media outlets, it maximizes or keeps constant the bias gap. In particular, as it is of relatively higher quality to the media outlets, it incurs lower costs in media bias adjustment.

The rest of this paper is organized as follows. Section 2 discusses the novel features of this paper compared to previous studies. Section 3 describes the model and analyzes media bias. Section 4 concludes this article.

II. RELATED LITERATURE

Economic models of media bias involve determinants of its supply, such as preferences of journalists or media owners, or of its demand, such as consumers' beliefs or preferences.[4] This paper provides a theory of media bias in the demand-side approach, employing a location model.[5]

Most studies, including Baron (2006) and Gentzkow & Shapiro (2006), have interpreted media quality as the accuracy of the news item. Baron (2006) considers quality as an ability of a media outlet to investigate the true state of the world. Gentzkow & Shapiro (2006) and Gentzkow, et al. (2015) added honesty in reporting to that definition, considering consumers' feedback. According to those studies, a high-quality media outlet "observes the state directly and reports it honestly" and a normal quality media "observes a noisy signal and reports strategically" (Gentzkow, et al., 2015). Thus, in those studies, "lower quality" implies "more bias" or quality is inversely proportional to accuracy. Mullainathan & Shleifer (2005) consider not only pure information but also the presentation of that information as demanded by consumers. However, they did not define quality as beyond the accuracy of a news item. When media quality is treated in this way, the quality adjustment becomes equivalent to bias adjustment.

However, in this paper, I assume that media quality is a transport (delivery) technology that improves the consumer's cognition of news. From the perspective of academics on journalism, Lacy & Rosenstiel (2015) describe that "Overall, the demand approach toward journalism quality aggregates individual consumer's perceptions of how well journalism serves their needs and wants. This relativistic approach helps explain the arguments that quality cannot be measured because it is subjective." These descriptions are more consistent with the definition of media quality in this paper, beyond accuracy.

The seminal models by Hotelling (1929) and d'Aspremont et al. (1979), and a number of subsequent papers assume the symmetric transport rates in the location model. In contrast, in the model of this paper, the qualities of the digital intermediary and media outlets are represented by the different transport rates. The idea of interpreting asymmetric quality as asymmetric transport rate follows the concept of Launhardt (1885) which Ferreira & Thisse (1996) introduced and analyzed, as mentioned earlier. However, they present only the symmetric location

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[4] Gentzkow et al. (2015) provides a literature review on models of media bias.

[5] As Hamilton (2004, 73) put it, "Political bias in media content is similar to product differentiation."

case of two firms,[6] while this paper analyzes the asymmetric case between media outlets and a digital intermediary under given prices.

So far, there is disagreement among economists on the effects of competition on media bias. In the demand-side studies on media bias, representative ones are Mullainathan & Shleifer (2005) who claim that competition increases bias and Gentzkow & Shapiro (2006) who argue that competition lowers bias.[7] In contrast, this paper argues that if a digital intermediary coexists with media outlets, it dominates the effects of the competition between media outlets.

Guo & Lai (2015), who employ the framework of Mullainathan & Shleifer (2005), argue that introducing a public-interest media outlet to duopolistic private media outlets can reduce the equilibrium bias by lowering the price of news. Because the private outlets may be afraid to lose consumers in the center of the political spectrum and so reduce their bias. They also claim that the policy of optimal subsidy for accurate reports can reduce media bias. Guo & Lai (2014) argue that the bias of advertisers may strengthen media bias. The public-interest media outlet, the subsidizer, and the advertisers in Guo & Lai (2014, 2015) are all analogous to the digital intermediary in this paper. The digital intermediary in this paper can play all the above roles, and not only reduce or increase but also keep constant the media bias.

III. MODEL

1. Assumption for Model

News consumers get two kinds of disutility when consuming news. The first is from the psychological distance between their bias and the media outlet's bias. The second is from their efforts needed for perceiving the information of the news. In the latter regard, media quality is defined as the ability to reduce consumers' efforts

[6] "Ideally, the analysis should be developed for any location pair but this turns out to be especially cumbersome." (Ferreira & Thisse, 1996, p. 492)

[7] Chan & Suen (2009) and Anderson & McLaren (2012) argue along the line of Gentzkow & Shapiro (2006). Bernhardt et al. (2008) and Burke (2008), and Stone (2011) have a same view as Mullainathan & Shleifer (2005). Besides, Anand et al. (2007) claim that more competition does not change media bias.

resulting in disutility[8] by a better-delivered set of information, independent of media bias. Therefore, the higher the quality of media outlet or the smaller the difference of bias between the media outlet and the consumer, the greater the utility of news consumers.

Consumers are evenly distributed over the real interval $[0, 1]$, depending on their political preferences. 0 and 1 represent the extreme left and the extreme right, respectively, and each consumer consumes N news items from only one provider.

There exist two profit-maximizing news media outlets, 'M1' and 'M2', and a digital intermediary, 'G' in the news market. x_M and x_G denotes the bias of media outlet $M \in \{1.2\}$ and the bias of G. Without loss of generality, it is assumed that $x_1 \leq x_2$; let $x_1 = a$ and $x_2 = 1 - b$ with $a \geq 0$ and $b \geq 0$, and $a + b \leq 1$. M1, M2, and *G*, each provide N news items to consumers. The digital intermediary, *G*, has no inherent bias and just relays the news items produced by M1 and M2 to consumers. *G* supplies N news items which are evenly mixed to consumers.[9] Thus, x_G is $(a + 1 - b)/2$.

Consumer price is fixed at p_c and the postpaid ad price $p > 0$ is also exogenously fixed. M1 and M2, and *G* provide news items free of charge to consumers $(p_c = 0)$, and get revenue only from one advertiser. These assumptions reflect the general characteristics of the digital news market.

The additional assumptions for *G* are as follows. *G*, like most digital intermediaries in the real world, uses news items as a kind of loss leader to its platform. *G* places importance on securing demand rather than profit in providing news business and gets the secondary income from the other business on its platform by those who visit its platform to consume the news items. $R > 0$ denotes the secondary income rate for the demand that *G* acquires through the news service business. *G* pays evenly to each media outlet for the supply of news items in

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[8] Concerning the efforts resulting in disutility, the model refers to the idea of Kahneman (2003) who proposes that "The difference in effort provides the most useful indications of whether a given mental process should be assigned to System 1 (intuition) or System 2 (reasoning)."

[9] The intermediary, who receives the original news items from both media outlets and supplies them to consumers, can re-adjust the average bias of the news items by editing. This case is beyond the scope of this paper.

proportion to the total number of news views consumed on its platform at the postpaid rate, k, irrespective of the number of news views of each outlet. Each media outlet provides news items to *G* unless its profit decreases with k, compared to when there is no deal with *G*.

$t_M > 0$ and $t_G > 0$ denote the transport rate of media outlets and the digital intermediary, respectively. Lower t_M and t_G represent the higher transport technology. Thus, t is an inverse measure of quality.

k, a, and b are choice variables for digital intermediary *G* and media outlet M1 and M2, respectively. The decision of k and the decisions of a and b are sequential: First, the digital intermediary chooses the level of k. Then, each media outlet respectively determines a and b.

Then, we consider the following three cases according to the quality orders between media outlets of symmetric quality and *G*: ① $t_G > t_M$; ② $t_G = t_M$; ③ $t_G < t_M$. These cases may occur due to such as the following differences between the media outlets and the digital intermediary: opportunity to compare the various views; interface; editing or categorizing news items reflecting consumers' responses[10]; network speed; server capacity, etc. If consumers incur searching costs when consuming the digital intermediary's news items, or if the consumer benefits from the digital intermediary's news customizing, they can also affect the above cases. For example, case ① can be where the consumer's searching cost at *G* is high enough. Case ③ is possible where the consumers' benefits of *G*'s categorizing or customizing of news is big enough or when *G* provides a much better opportunity to compare the various views, network speed, server capacity, and interfaces, etc. From now on, let us check and analyze the bias differentiation in each of the above-mentioned cases.

2. Analysis

First, let us think about what happens when the two media outlets compete without the digital intermediary. The utility of a news consumer i at x_i is: $u_i^M = \bar{u} - p_c - t_M(x_M - x_i)^2$. Under the symmetric quality, we have a simple result: the

[10] In many cases, digital intermediaries are better than the traditional media outlets in news classification by sector or age or region or popularity of news, etc.

minimum bias differentiation at $x_1 = x_2 = (1/2)$. In contrast, Yang (2020), who uses the same utility function and a similar definition of quality as in this paper, studies the media bias with given prices, asymmetric quality, and location cost depending on the quality. Yang (2020) shows that an equilibrium media bias exists unless the cost of a high-quality media outlet for adjusting bias is small enough; the size of the equilibrium bias gap between media outlets depends on the quality difference.

Next, let us look when introducing a digital intermediary *G* to the news market. The utility of a news consumer i at x_i is:

$$u_i^M = \bar{u} - p_c - t_M(x_M - x_i)^2 \quad \text{and} \quad u_i^G = \bar{u} - p_c - t_G(x_G - x_i)^2 \qquad \#(1)$$ [11]

In addition, it is assumed that when $u_i^M = u_i^G$, consumer *i* consumes only the news items of media outlets, not of *G*. This assumption reflects that consumers prefer to consume news items through the original producer rather than the intermediary.

1) The Cases Where $t_G > t_M$ and $t_G = t_M$

When $t_G > t_M$, consumer i's utility, u_i are: $u_i^1 = \bar{u} - p_c - t_M(x_1 - x_i)^2$; $u_i^2 = \bar{u} - p_c - t_M(x_2 - x_i)^2$; $u_i^G = \bar{u} - p_c - t_G\left(\frac{x_1+x_2}{2} - x_i\right)^2$.

The marginal consumer, x, satisfy the following equations where $\sqrt{t_M/t_G} = \theta < 1$.

$$\theta^2(a-x)^2 = \theta^2(1-b-x)^2 = \left(\frac{a+1-b}{2} - x\right)^2 \qquad \#(2)$$

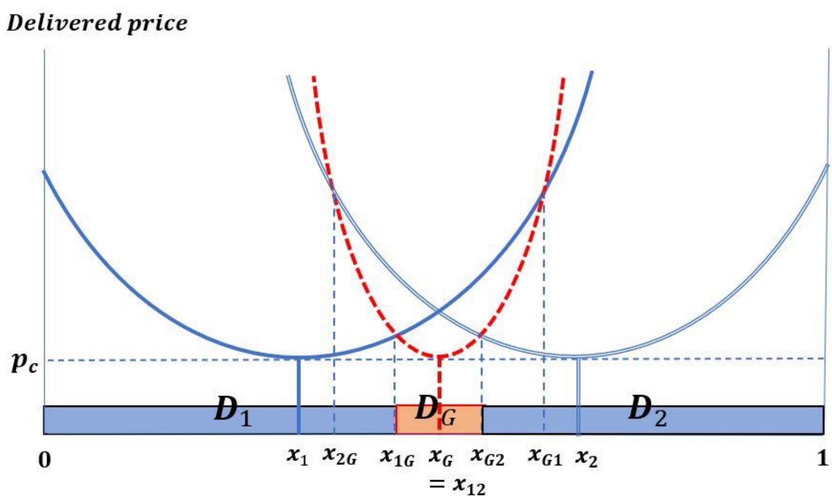
Then, marginal consumers, x's are: $x_{1G} = \frac{1+a-b+2a\theta}{2(1+\theta)}$ and $x_{G1} = \frac{1+a-b-2a\theta}{2(1-\theta)}$

[11] Greiner (2010), who analyzes the equilibrium amount of entertainment in news coverage of newspapers and television stations, uses a similar utility function: $u_j = \bar{u} - p_j - k_j|x_j - x|$ where firms $j = 1, 2$. k_j is the cost parameter ($k_1 > k_2$). However, x_j denotes not location but the amount of production, so that cost functions are $C(x_1)$ and $C(1 - x_2)$.

when $u_i^1 = u_i^G$; $x_{2G} = \frac{1+a-b-2\theta(1-b)}{2(1-\theta)}$ and $x_{G2} = \frac{1+a-b+2\theta(1-b)}{2(1+\theta)}$ when $u_i^2 = u_i^G$; $x_{12} = x_G = \frac{1+a-b}{2}$ when $u_i^1 = u_i^2$. x_{1G} denotes the marginal consumer's location between M1 approaching from left-below and *G* approaching from the left-above and x_{G1} denotes the opposite.

If $a = 1 - b$, *G* cannot have any demand at all by the previous assumption, and thus, *G* does not exist in the market. If $a < 1 - b$, the order of x's is $x_{1G} \leq x_G = x_{12} \leq x_{G2}$, and $x_1 \leq x_{2G} \leq x_{1G}$ or $x_{2G} \leq x_1 \leq x_{1G}$, and $x_{G2} \leq x_{G1} \leq x_2$ or $x_{G2} \leq x_2 \leq x_{G1}$. Hence, the demands and profits of M1, M2, and *G* are as follows and shown in <Figure 1>. In the figure, the delivered price is individual consumer's total disutility, $p_c + t_M(x_M - x_i)^2$ or $p_c + t_G(x_G - x_i)^2$.

<Figure 1>



$$D_1 = \frac{(1 + a - b) + 2a\theta}{2(1 + \theta)}, \quad D_2 = \frac{(1 - a + b) + 2b\theta}{2(1 + \theta)}, \quad D_G = \frac{(1 - a - b)\theta}{1 + \theta} \qquad \#(3)$$

$$\pi_M = pD_M + kD_G, \qquad \pi_G = (p + R - 2k)D_G \qquad \#(4)$$

To solve the choices of *G* and both media outlets, let us check the optimal k.

$$\frac{d\pi_1}{da} = \frac{d\pi_2}{db} = \frac{1}{2(1+\theta)}\{(1+2\theta)p - 2\theta k\} \quad \#(5)$$

Both M1 and M2 accept only $k \geq \frac{p}{2}$ and we can have 3 cases depending on k with regard to the differentiation of media bias between media outlets, as shown in <Table 1>.

<Table 1> The Differentiation of Media Bias According to k When $t_G > t_M$

Case	$\frac{d\pi_1}{da}$	$\frac{d\pi_2}{db}$	k	(x_1, x_2)	Demand of G, D_G
①	(+)	(+)	$\left[\frac{1}{2}p, \frac{1+2\theta}{2\theta}p\right)$	$\left(\frac{1}{2}, \frac{1}{2}\right)$	0
②	0	0	$\frac{1+2\theta}{2\theta}p$	$(a, 1-b)$	$\frac{(1-a-b)\theta}{1+\theta}$
③	(−)	(−)	$\left(\frac{1+2\theta}{2\theta}p, \infty\right)$	$(0, 1)$	$\frac{\theta}{1+\theta}$

A profit-maximizing *G* can offer $k \leq \frac{p+R}{2}$. If $\frac{p+R}{2} < \frac{1+2\theta}{2\theta}p$, i.e., $R < \left(\frac{1+\theta}{\theta}\right)p$, it can offer $k \in \left[\frac{1}{2}p, \frac{p+R}{2}\right]$ but has no demand when M1 and M2 differentiate minimally since $u_i^M = u_i^G$ for all consumer *i*. Thus, Case ① does not occur so that *G* exits from or does not enter the market when $R < \left(\frac{1+\theta}{\theta}\right)p$.

If $R \geq \frac{(1+\theta)}{\theta}p$, both Case ② and Case ③ can occur by $k \in \left[\frac{1+2\theta}{2\theta}p, \frac{p+R}{2}\right]$. When $k = \frac{1+2\theta}{2\theta}p$, both outlets have no incentive to change initial bias, so that the bias competition disappears and *G* gets positive demand, $\frac{(1-a-b)\theta}{1+\theta}$. When $\frac{1+2\theta}{2\theta}p < k \leq \frac{p+R}{2}$, *G* can maximize the media bias differentiation with $D_G = \frac{\theta}{1+\theta}$.

The results in the case where $t_G = t_M$ are as same as those in the above case where $t_G > t_M$ except for a decrease of the critical value of k from $\frac{1+2\theta}{2\theta}p$ to $\frac{3}{2}p$ that determines the signs of $\frac{d\pi_1}{da}$ and $\frac{d\pi_2}{db}$.

[PROPOSITION 1] *Introducing an intermediary that uses news items as a loss leader for its platform into the digital news market of duopoly media outlets under the fixed price, the intermediary not dominating media outlets in quality:*
(i) coexists only when $R \geq \frac{1+\theta}{\theta}p$*;*
(ii) causes maximum differentiation of media bias with $k > \frac{1+2\theta}{2\theta}p$ *when* $t_G > t_M$ *and with* $k > \frac{3}{2}p$ *when* $t_G = t_M$*;*
(iii) can keep constant the bias of media outlets with $k = \frac{1+2\theta}{2\theta}p$ *when* $t_G > t_M$ *and with* $k = \frac{3}{2}p$ *when* $t_G = t_M$*.*

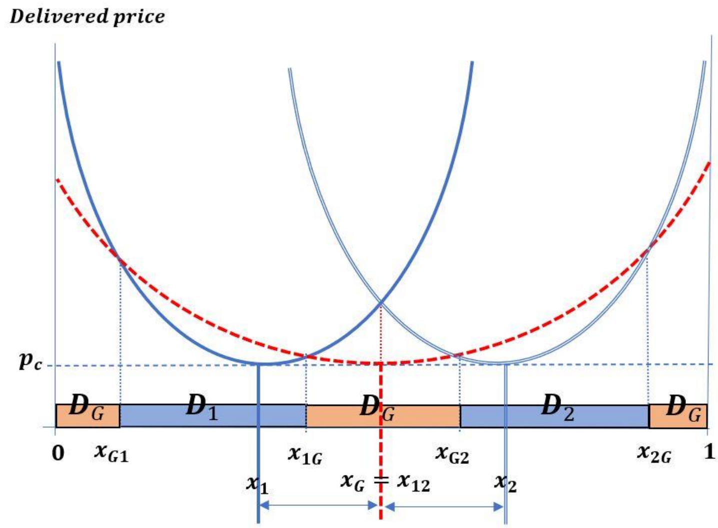
2) The Case Where $t_G < t_M$

Now, let us see the case when *G* has higher transport technology than media outlets. When $t_G < t_M$, marginal consumer, x, satisfy the following equations.

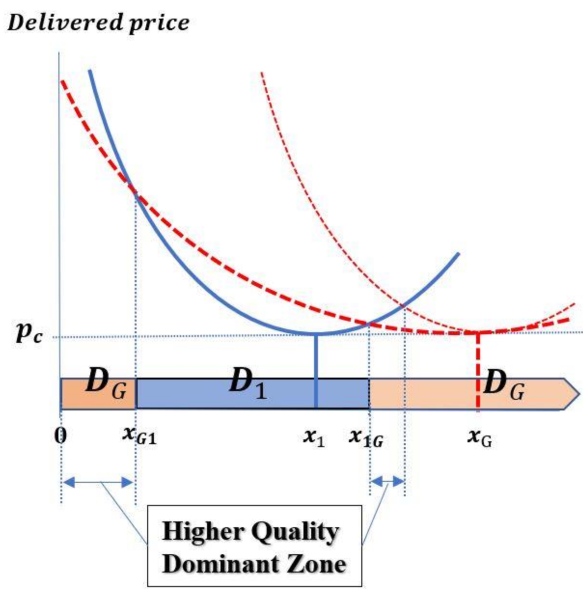
$$(a-x)^2 = (1-b-x)^2 = \theta^2\left(\frac{a+\ 1-b}{2} - x\right)^2 \text{ where } \sqrt{t_G/t_M} = \theta < 1. \quad \#(6)$$

Then, marginal consumers, x's are: $x_{G1} = \frac{2a-\theta(1+a-b)}{2(1-\theta)}$ and $x_{1G} = \frac{2a+\theta(1+a-b)}{2(1+\theta)}$ when $u_i^1 = u_i^G$; $x_{G2} = \frac{2(1-b)+\theta(1+a-b)}{2(1+\theta)}$ and $x_{2G} = \frac{2(1-b)-\theta(1+a-b)}{2(1-\theta)}$ when $u_i^2 = u_i^G$; $x_{12} = x_G = \frac{1+a-b}{2}$ when $u_i^1 = u_i^2$. If $a = 1-b$, *G* can get the market-wide demand with $k \geq \frac{1}{2}p$. If $a < 1-b$, $x_{G1} < x_1 < x_{1G} < x_G = x_{12} < x_{G2} < x_2 < x_{2G}$ and the demands, D_1, D_2 and D_G are as in <Figure 2> below. <Figure 2-1> shows that quality, defined as the ability to help consumers to interpret information by better delivering information through news, including providing various views, is the more important criterion if the bias gap between media outlets and consumers is more than a certain size.

<Figure 2>



<Figure 2-1>



When $a < 1 - b$, we can have three subdivided cases according to θ as the following <Table 2>. θ_1 and θ_2 in the table are the critical values of θ that determine whether a demand for *G* exists in the hinterland of M1 or M2, respectively. Without loss of generality, it is assumed that $a \geq b$ in all the following discussions of this paper. Then $\theta_1 \geq \theta_2$, and $b < \frac{1}{2}$. The opposite case is symmetrical. Thereby, the demands of M1, M2, and *G* are as <Table 2> below.

<Table 2> The demands of Media Outlets and Digital Intermediary When $t_G < t_M$

$$\theta_1 = \frac{2a}{(1+a-b)}, \quad \theta_2 = \frac{2b}{(1-a+b)}, \quad \theta_1 \geq \theta_2$$

	①	②	③
$\boldsymbol{\theta}$	$\mathbf{0 < \theta \leq \theta_2}$	$\boldsymbol{\theta_2 < \theta \leq \theta_1}$	$\boldsymbol{\theta_1 < \theta < 1}$
$\boldsymbol{x_{G1}}$	$x_{G1} \geq 0 \ (0 < \theta \leq \theta_1)$	$x_{G1} \geq 0 \ (0 < \theta \leq \theta_1)$	$x_{G1} < 0 \ (\theta_1 < \theta < 1)$
$\boldsymbol{x_{2G}}$	$x_{2G} \leq 1 \ (0 < \theta \leq \theta_2)$	$x_{2G} > 1 \ (\theta_2 < \theta < 1)$	$x_{2G} > 1 \ (\theta_2 < \theta < 1)$
$\boldsymbol{D_1}$	$x_{1G} - x_{G1}$ $\frac{\theta(1-b-a)}{1-\theta^2}$	$x_{1G} - x_{G1}$ $\frac{\theta(1-b-a)}{1-\theta^2}$	x_{1G} $\frac{2a+\theta(1+a-b)}{2(1+\theta)}$
$\boldsymbol{D_2}$	$x_{2G} - x_{G2}$ $\frac{\theta(1-b-a)}{1-\theta^2}$	$1 - x_{G2}$ $\frac{2b+\theta(1-a+b)}{2(1+\theta)}$	$1 - x_{G2}$ $\frac{2b+\theta(1-a+b)}{2(1+\theta)}$
$\boldsymbol{D_G}$	$1 - \frac{2\theta(1-b-a)}{1-\theta^2}$	$1 - \frac{2b+\theta(1-a+b)}{2(1+\theta)}$ $- \frac{\theta(1-b-a)}{1-\theta^2}$	$\frac{1-b-a}{1+\theta}$

* If $x_{G1} < 0$ and $x_{2G} \leq 1$, $\theta \in (\theta_1, 1)$ and $\theta \in (0, \theta_2]$. But $(\theta_1, 1) \cap (0, \theta_2] = \emptyset$ since $\theta_1 \geq \theta_2$.

* When the symmetric case, i.e., $a = b$, $\theta_1 = \theta_2$, so that case ② in the above table is not needed.

Here, note that, in the model, the smaller the inter-media bias gap, or the higher the relative quality of *G*, the demand for *G* also occurs in the hinterland of each media outlet. As mentioned earlier and shown in <Fig. 2-1>, according to the

Launhardt Model, consumers buy the product which provides a larger total utility reflecting the quality, even if it is farther from their preferences. Likewise, news consumers consume news item that provides less disutility, comprehensively considering the quality and their political bias that yield the consumers' total utility of news.

It can imply the recent trend that, especially in Korea, among the consumers with extreme political bias, a sizable portion of consumers no longer consume traditional media outlets with biases closer to theirs.[12] And then, we can predict that those consumers eventually consume news items through digital intermediaries.

From now on, let us check the optimal k for media outlets and G, and how both media outlets differentiate bias depending on k. First, let us check the changes in the profits of media outlets depending on k at a given θ. The profits are: $\pi_M = pD_M + kD_G$ and $\pi_G = (p + R - 2k)D_G$.

When $0 < \theta \leq \theta_2$, $\frac{d\pi_1}{da} = \frac{d\pi_2}{db} = \frac{-\theta(p-2k)}{1-\theta^2}$. Thus, if $k \geq \frac{1}{2}p$, $\frac{d\pi_1}{da} \geq 0$ and $\frac{d\pi_2}{db} \geq 0$ while if $k < \frac{1}{2}p$, $\frac{d\pi_1}{da} < 0$ and $\frac{d\pi_2}{db} < 0$.

When $\theta_1 < \theta < 1$, $\frac{d\pi_1}{da} = \frac{d\pi_2}{db} = \frac{(2+\theta)p-2k}{2(\theta+1)}$. Thus, if $k \leq \frac{2+\theta}{2}p$, $\frac{d\pi_1}{da} \geq 0$ and $\frac{d\pi_2}{db} \geq 0$ while if $k > \frac{2+\theta}{2}p$, $\frac{d\pi_1}{da} < 0$ and $\frac{d\pi_2}{db} < 0$.

When $\theta_2 < \theta \leq \theta_1$, $\frac{d\pi_1}{da} = \frac{-\theta\{2p-k(3-\theta)\}}{2(1-\theta^2)}$ and $\frac{d\pi_2}{db} = \frac{p(2-\theta-\theta^2)-k(2-3\theta-\theta^2)}{2(1-\theta^2)}$. Thus, $\frac{d\pi_1}{da} \geq 0$ if $k \geq \frac{2}{3-\theta}p$, and $\frac{d\pi_1}{da} < 0$ if $k < \frac{2}{3-\theta}p$. In contrast, the sign of $\frac{d\pi_2}{db}$ needs a closer look. $\frac{d\pi_2}{db}$ is always positive when $2 - 3\theta - \theta^2 < 0$, since $2 - \theta - \theta^2 > 0$ when $0 < \theta < 1$. Hence, always $\frac{d\pi_2}{db} > 0$ irrespective of k

[12] Recently, more readers with extreme political bias have quit consuming news from media outlets with political biases closer to theirs. See the following articles for the cases: "Unprecedented Consumer Distrust, Agonizing Progressive Media Outlets" (Kang, 2017); "When can the Chosunilbo, which has lost 200,000 readers, wake up?" (Cho, 2017). This trend can also be attributed to 'the widespread distrust of consumers about traditional media' (Zingales, 2016) and the advent of digital intermediaries that provide news content.

when $\frac{-3+\sqrt{17}}{2} \leq \theta < 1$. But, When $0 < \theta < \frac{-3+\sqrt{17}}{2}$, $\frac{d\pi_2}{db} \geq 0$ if $k \leq \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$ and $\frac{d\pi_2}{db} < 0$ if $k > \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$.

Next, we find the equilibrium locations of media outlets with the optimal k. Note, the above critical values of k which determine the locations of media outlets, and the following size order:

$$\frac{1}{2}p < \frac{2}{3-\theta}p < \frac{2+\theta}{2}p < \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p \quad \text{when} \quad 0 < \theta < \frac{-3+\sqrt{17}}{2} \qquad \#(7)$$

$$\frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p < \frac{1}{2}p < \frac{2}{3-\theta} < \frac{2+\theta}{2}p \quad \text{when} \quad \frac{-3+\sqrt{17}}{2} \leq \theta < 1 \qquad \#(8)$$

The location of media outlets according to the value of θ and k are as shown in <Table 3>. The location pairs in <Table 3> take into account the changes in θ_1 and θ_2 due to the changes in a and b. (See the Appendix for a more detailed description of <Table 3>.)

A profit-maximizing G can offer $k \leq \frac{p+R}{2}$. Thus, the possible options of G for k are dependent upon the size of R. The critical values of k are: $\frac{1}{2}p$ when $0 < \theta \leq \theta_2$; $\frac{2+\theta}{2}p$ when $\theta_1 < \theta < 1$; $\frac{2}{3-\theta}p$ and $\frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$ when $\theta_2 < \theta \leq \theta_1$. To put it simply, if $\frac{p+R}{2} > \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$ and $0 < \theta \leq \frac{1}{2}\left(-3+\sqrt{17}\right)$ as in #(7), or if $\frac{p+R}{2} > \frac{2+\theta}{2}p$ and $\frac{-3+\sqrt{17}}{2} \leq \theta < 1$ as in #(8), all the cases of media bias differentiation in <Table 3> are possible. In contrast, if $\frac{p+R}{2} < \frac{2}{3-\theta}p$, Case ①, ②, ③, and ⑦ in <Table 3> are possible.

<Table 3> The Differentiation of Media Bias According to k and θ

θ	k	(x_1, x_2)	Demand of G, D_G	Case
$0 < \theta \le \theta_2$	$\frac{1}{2}p$	$(a, 1-b)$	$1 - \frac{2\theta(1-b-a)}{1-\theta^2}$	①
	$\left(\frac{1}{2}p, \infty\right)$	$(\frac{1}{2}, \frac{1}{2})$	1	②
$\theta_2 < \theta \le \theta_1$	$\left[\frac{1}{2}p, \frac{2}{3-\theta}p\right]$	$(\frac{1}{2}, \frac{1}{2})$	1	③
$\frac{1}{2}(-3+\sqrt{17}) \le \theta < 1$	$\left(\frac{2}{3-\theta}p, \infty\right)$	$(\frac{1}{2}, \frac{1}{2})$	1	④
$0 < \theta \le \frac{1}{2}(-3+\sqrt{17})$	$\left(\frac{2}{3-\theta}p, \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p\right]$	$(\frac{1}{2}, \frac{1}{2})$	1	⑤
	$\left(\frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p, \infty\right)$	(1,1)	1	⑥
$\theta_1 < \theta < 1$	$\left[\frac{1}{2}p, \frac{2+\theta}{2}p\right)$	$(\frac{1}{2}, \frac{1}{2})$	1	⑦
	$\frac{2+\theta}{2}p$	$(a, 1-b)$	$\frac{1-b-a}{\theta+1}$	⑧
	$\left(\frac{2+\theta}{2}p, \infty\right)$	(0,1)	$\frac{1}{\theta+1}$	⑨

G can do increase or decrease or fix the media bias gap according to the range of θ by raising or lowering $k \in \left[\frac{1}{2}p, \frac{p+R}{2}\right]$. Describing in more detail, when $k = \frac{1}{2}p$ and $0 < \theta \le \theta_2$, or when $k = \frac{2+\theta}{2}p$ and $\theta_1 < \theta < 1$, both outlets do not change their initial locations. When $\frac{2+\theta}{2}p < k \le \frac{p+R}{2}$ and $\theta_1 < \theta < 1$, media outlets differentiate maximally. In the rest of the cases, media outlets differentiate minimally at the center point or the endpoint while *G* gets the whole market demand. The optimal k for *G* which wish maximum demand with lower cost are

$\left(\frac{1}{2}p+\varepsilon\right)$ with $\varepsilon > 0$ when $0 < \theta \leq \theta_2$ and $\frac{1}{2}p$ when $\theta_2 < \theta < 1$. The above discussion is summarized in Proposition 2.

[PROPOSITION 2] *Introducing an intermediary that uses news items as a loss leader for its platform into the digital news market of duopoly media outlets under the fixed price, the profit maximizing intermediary dominating media outlets in quality minimizes the bias gap between media outlets. If the intermediary tolerates a loss of demand, it can control media bias by adjusting the purchase price of news items of media outlets within its secondary income, as follows. It can maximize or keep constant the bias gap when* $\theta_1 < \theta < 1$, *and keep constant the bias gap when* $0 < \theta \leq \theta_2$.

Proposition 2 shows that when the intermediary dominates media outlets in quality, media outlets become virtually subordinate to the intermediary, and the diversity of public opinion can be weakened. In Proposition 2, the maximum differentiation of media bias can occur only when $\theta_1 < \theta < 1$. However, even when otherwise, the intermediary can maximize the bias gap between media outlets by intentionally lowering its quality to a level sufficient and then raising k. On the contrary, even when $0 < \theta \leq \theta_2$, if the media outlets accept $k < \frac{1}{2}p$ for some reasons, the digital intermediary can maximize the bias gap. For example, the media outlets can accept $k < \frac{1}{2}p$ if the benefits of the exposure of its news items on the intermediary's platform are larger enough than a decrease in profit. These benefits can be interpreted such as the expansion of those outlets' influence.[13]

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[13] Numerous media outlets that have low demand want to provide their news items to the platforms of digital intermediaries, free of charge. It is because they can get more influence by more exposure of their news items on those platforms. In 2019, 527 news media outlets applied to provide their news content to Naver and Kakao, the largest digital intermediaries in South Korea. But Naver and Kakao have accepted only 32 of the media outlets as partners in January 2020. In addition, most of the 527 media outlets had offered free provision of news items to Naver and Kakao.

In addition, the critical values of k which determines the bias differentiation of media outlets are: $\frac{1+2\theta}{2\theta}p$ when $t_G > t_M$; $\frac{3}{2}p$ when $t_G = t_M$; $\frac{1}{2}p$, $\frac{2}{3-\theta}p$, $\frac{2+\theta}{2}p$, and $\frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$ when $t_G < t_M$. Comparing these values, the higher the relative quality of *G* to media outlets, the smaller the k.

[PROPOSITION 3] *When an intermediary coexists with duopolistic media outlets in the digital news market, the higher the quality of the digital intermediary compared to the media outlets, the lower the cost for the intermediary necessary to adjust media bias.*

IV. CONCLUSION

This paper attempts to study the effect of competition on differentiating media bias under conditions characteristic of the news market in the digital age. Therefore, assumptions for the model, such as price and quality assumptions, correspond to the real digital news market, especially in Korea.

Another new feature of this paper is to assume media quality to be an ability to help the cognition of news items by news consumers. Thereby, we can analyze media quality and media bias jointly while understanding media quality independently of media bias.

This paper shows that a digital intermediary such as Google or Naver that runs news service pages may affect media bias. This is a new challenge in economic research on media bias. The results of the model show that the digital intermediary having high ICT (Information and Communication Technology) tends to minimize the bias gap between media outlets, but also imply that the digital intermediary can maximize or adjust the bias gap according to its intention.

The findings of this paper propose several policy options for the diversity of public opinion and news consumers' information welfare. First, the results imply that when a digital intermediary with high ICT capabilities has greater media power than any particular media outlet, the positive effects of media outlets' competition can be weakened. This likelihood is more significant when media capturers, such as political forces, wish to impose certain biases on the digital intermediary. If a media capturer affects the digital intermediary's news platform, it will be a serious threat to democracy. Thus, there also needs to consider protecting digital intermediaries from the media capturers who wish to induce media bias to suit their interests.

Second, the large quality gap between the media outlets and the digital intermediary could make the digital intermediary capture media outlets with ease due to lower cost. Therefore, to minimize the possibility of public opinion distortion by the digital intermediary, there need various policy measures enhancing media outlets' quality.

This study can be improved further in several ways. One possible extension is to study media bias when the digital intermediary customizes news items for consumers. Second, it would be interesting to incorporate asymmetric qualities of media outlets that coexist with a digital intermediary into the model. Third, particularly as an independent future research agenda, it can be considered to develop a theoretical model with the different reserved utilities of consumers between the media outlets and a digital firm or with more sophisticated media quality indicators.[14] Finally, extensions to the model with more media outlets or more digital intermediaries can be considered, as well as empirical tests of this paper's theoretical implications and predictions.

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APPENDIX

A more detailed description of <Table 3> is as follows. Given θ and k, the location strategy of media outlet depends on the value of θ_1 and θ_2 reflecting the current locations, a and b.

(i) The case where $0 < \theta \leq \theta_2$

If $k = \frac{1}{2}p$, both outlets not to change the initial bias. If $k > \frac{1}{2}p$, both outlets locate together on the center point.

(ii) The case where $\theta_2 < \theta \leq \theta_1$

If $\frac{1}{2}p \leq k \leq \frac{2}{3-\theta}p$, M1 decreases or does not change a while M2 increases b. Thereby, θ_2 increases since $\frac{d\theta_2}{da} < \frac{d\theta_2}{db}$ and then both outlets compete where $0 < \theta \leq \theta_2$. Hence, both outlets increase a and b, and locate at $(\frac{1}{2})$.

When $k > \frac{2}{3-\theta}p$, thus, we have two subdivided cases where $\frac{1}{2}\left(-3+\sqrt{17}\right) \leq \theta < 1$ and where $0 < \theta < \frac{1}{2}\left(-3+\sqrt{17}\right)$.

Where $\frac{1}{2}\left(-3+\sqrt{17}\right) \leq \theta < 1$, both outlets locate at $(\frac{1}{2})$. Where $0 < \theta < \frac{1}{2}\left(-3+\sqrt{17}\right)$, if $\frac{2}{3-\theta}p < k < \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$, both outlets locate at $(\frac{1}{2})$. If $k = \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$, M2 does not change b but M1 increases a, so that $\theta_2 < \theta \leq \theta_1$ changes to $0 < \theta \leq \theta_2$. Where $0 < \theta \leq \theta_2$, both outlets locate at the center point $(\frac{1}{2})$. If $k > \frac{2-\theta-\theta^2}{2-3\theta-\theta^2}p$, M1 increases a while M2 decreases b. And the condition that $\theta_2 < \theta \leq \theta_1$ does not change since $\frac{d\theta_1}{da} + \frac{d\theta_1}{d(-b)} > 0$ and $\frac{d\theta_2}{da} + \frac{d\theta_2}{d(-b)} < 0$. Therefore, both media outlets locate at the endpoint, 1.

(iii) The case where $\theta_1 < \theta < 1$

If $\frac{1}{2}p \leq k < \frac{2+\theta}{2}p$, both outlets increase a and b, respectively. However, $\theta_1 < \theta < 1$ changes to $\theta_2 < \theta \leq \theta_1$ by increasing θ_1.Thus, the results of this case are shown in the above case (ii). (Note that $\frac{2}{3-\theta}p < \frac{2+\theta}{2}p$.)

If $k = \left(\frac{2+\theta}{2}\right)p$, both outlets do not change the initial bias. If $k > \left(\frac{2+\theta}{2}\right)p$, M1 and M2 locate at 0 and 1, respectively.