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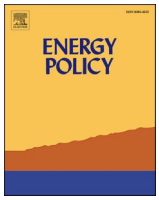

Voices of transitions: Korea's online news media and user comments on the energy transition

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ABSTRACT

It is important to understand stakeholders' attitudes toward energy transition policies, or indeed toward any government proposal. Online news platforms are agoras where media and people interact, so they appear to be a rich vein for mining media and public attitudes toward energy transition. We collected online news articles and comments with the keyword "energy transition," along with such commenters' activity histories, from the largest Korean online news aggregator during the July 2021 to July 2022 shift in the government. Utilizing advanced machine learning approaches, we examined the media's evaluation of energy transition, users' emotions regarding it, and the influence of various features on commenters' emotions and elaborations in comments. We found that intense negative emotions dominated news comments about the energy transition. However, our analysis of users' historical activities found that the commenters were a raging political crowd who expressed intense negative emotions about many social and political issues. Furthermore, our application of Catboost regression analysis demonstrates how news framing can facilitate deliberation by relieving the intensity of emotions and enhancing users' deliberation. Our findings suggest being cautious about using online news platform data to gauge media and public attitudes toward energy transition. The findings also highlight the need to use comprehensive datasets and approaches to avoid misunderstanding stakeholders' attitudes toward energy policy, as expressed in online spaces. These findings can guide future studies that use news comments to understand public attitudes toward energy transition policies or other contentious proposals.

1. Introduction

Stabilizing the climate requires a profound and radical transition in society. The energy transition, a shift in how energy is supplied, utilized, and distributed, is pivotal to climate stabilization (Sovacool, 2016). The varied paths of energy transition encompass radical technological changes with respect to which energy sources are dominant, resulting in winners and losers (Carley and Konisky, 2020). Thus, they often lead to public political debates about the winners and losers (Antal and Karhunmaa, 2018 Yun et al., 2022; Żuk, 2023).

The term "energy transition" was first used officially in Korea by the Moon Jae-in administration, which was in power from May 2017 to May 2022. The Moon administration prescribed mid- and long-term targets for a carbon-neutral society in law and developed and promoted proactive energy policy measures to attain those targets (MOE, 2022). The three pillars of the Moon administration's energy transition were the phaseout of old coal, the gradual phaseout of nuclear, and the expansion of renewables (IEA, 2020a; MOTIE, 2019).

These guiding principles for the Korean energy transition ignited debates and criticisms from various stakeholders and the public. The transition principles threatened the powerful position of the nuclear industry in the Korean economy (Kim and Jeon, 2020). In addition, Korea's electricity supply depends on a single integrated grid that was shaped around large-scale plants that generate reliable, predictable power. In contrast, generation from variable renewables like solar or wind power depends on the weather, so the expansion of such

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renewables without appropriate countermeasures such as back-up power plants or energy storage systems places the stability of the system at great risk (IEA, 2020b). Furthermore, lay people's criticisms have been provoked by fake news, such as alleged health risks from solar PV waste (Ha et al., 2022).

The change from a liberal (Moon Jae-in) to a conservative (Yoon Suk Yeol) administration in South Korea in May 2022 has shifted the fundamental emphasis of energy policies from renewable energy to nuclear power (The government of Korea, 2022). Unlike in previous presidential elections, candidates' ideas about the energy transition became important parts of the campaign. During the transition period from July 2021 to July 2022, energy transition policy was intensely discussed by the media and the public.

The public and the media are important stakeholders in energy policy. Stakeholder approval of a policy provides legitimacy, which enables rapid and smooth implementation (Mastroeni et al., 2023). The media can increase public awareness and change public attitudes about a policy or technology (Fabiani et al., 2023; Osička et al., 2020). Żuk (2023) highlighted the media's use of soft power in energy policy to "ensure that social preferences and the energy behavior of society are in line with the interests of power elites" (p. 572). Individuals' perceptions of specific energy conversion technologies or strategies for energy transition are shaped by the media. In other words, how the media frame technologies or strategies influences the public's perception (Delshad and Raymond, 2013; Heras-Saizarbitoria et al., 2011; Trisiah et al., 2022).

The shift from print newspapers to digital journalism has allowed the general public to participate in real-time deliberations about pertinent matters, so the media's influence is substantially augmented (Althaus and Tewksbury, 2002; Tewksbury and Althaus, 2000). While scholars in political communication have highlighted the potential for deliberative discourse (Dahlberg, 2001), they have also noted that the emotions expressed in comments may give rise to heightened irrational discourse (Rossini, 2020; Shah et al., 2017; Stroud et al., 2016). Media frames that provide interpretations of societal issues to individuals not only influence their thoughts, issue perception, and opinions (Druckman and Nelson, 2003; Gross, 2008; Valkenburg et al., 1999), but they also contribute to these emotional reactions (Kim and Cameron, 2011; Lecheler et al., 2013; Myers et al., 2012). News frames can thus shape the quality and nature of public deliberation about policy issues in the recently activated debate spaces of the media environment. However, despite the compelling evidence of framing effects on public opinion, only a few studies have explored the influence of framing on how people discuss energy policy with fellow citizens.

This study investigated media sentiment and online news users' emotions by analyzing news headlines and comments about the direction of the energy transition in Korea. It also analyzed commenters' historical activities to understand whether their revealed attitudes were related only to energy transition policy or were part of their underlying characteristics. It thus advances understanding of whether online comments are a reliable gauge of public attitudes toward public policy. Furthermore, this study delved into features that influence the emotions expressed in online comments.

This study unfolds as follows. First, it describes the potential of online news platforms to be a media agora where people capture important stakeholders' perceptions of energy transition. Next, it details the collected data, derived variables, and approaches. The results section presents media and user evaluations of energy transition in Korea, the relationship between the media's evaluation and users' emotions about energy transition, and the important features influencing users' emotions and activities. It concludes by discussing those findings and their policy implications.

2. Literature review

2.1. Online news platforms

Traditionally, the news media wielded considerable influence over the molding of public opinion as unidirectional communication channels (Gamson and Modigliani, 1989). There, thus has been substantial interest in the political orientations endorsed by news outlets and in the framing effects inherent to news media (Brewer, 2003; De Vreese et al., 2011; Matthes and Schemer, 2012; Simon and Jerit, 2007). News frames are interpretive patterns for categorizing and efficiently processing information. They emphasize certain aspects of reality and downplay others, ultimately shaping specific attributes, judgments, and decisions (e.g., Entman, 1993; Scheufele, 2000). The framing effect describes how media outlets and journalists can shape public understanding by presenting news stories in specific ways (Brewer and Gross, 2005; Gamson and Modigliani, 1989).

Numerous studies have revealed the profound impact of framing techniques on public perceptions, political attitudes, and emotional responses (Druckman and Nelson, 2003; Gross, 2008; Kim and Cameron, 2011; Lecheler et al., 2013; Myers et al., 2012; Valkenburg et al., 1999). In Lecheler et al. (2013), positive news framing was observed to generate enthusiasm that led to greater support for the political issue in question. Conversely, negative framing triggers feelings of anger, resulting in less favorable opinions. Studies have highlighted that exposure to news framing can evoke specific emotional reactions, which are the foundation of attitudes and opinions about government policy (Druckman and McDermott, 2008; Gross and D'ambrosio, 2004).

The online news era has shifted the paradigm. While news outlets' perspectives continue to affect the public, there has been a substantial increase in the influence wielded by the public as it participates in real-time deliberations about pertinent matters. A substantial body of scholarly inquiry has been dedicated to investigating the manner in which user-generated comments shape news readers' perceptions of the prevalent public sentiment about specific issues (Chun and Lee, 2017; Conlin and Roberts, 2016; Lee and Jang, 2010). For instance, empirical evidence demonstrates that when user comments overtly critique news articles, the perceived credibility of the news is downgraded (Naab et al., 2020). Furthermore, in Lee et al. (2021), participants exposed to user comments that reinforced their preexisting viewpoints rather than challenging their perspectives were inclined to construe the prevailing public opinion as aligned with their own stance. This led to the polarization of opinions. All of this substantiates the notion that comments on news articles can influence individual opinions by shaping perceptions of the existing opinion climate.

The substantial influence of user comments on individuals' understanding of the news and the framing of issues has led to apprehension about unmoderated commentary systems. Online news comments can amplify expressions of hatred, exacerbate intergroup conflicts, obfuscate the essence of an article, and disseminate misleading information to audiences. Empirical findings have consistently demonstrated that uncivil comments degrade the perceived quality and credibility of news articles and the credibility of associated policies (Masullo and Kim, 2021; Prochazka et al., 2018; Waddell, 2020). Such comments also contribute to the deepening polarization of public opinion (Anderson et al., 2014). In light of these concerns and empirical evidence, numerous news organizations have taken measures to restrict and oversee their comment sections. For instance, *The New York Times* permits comments on only 15% of its articles, all of which are subject to administrative scrutiny prior to publication. In a novel approach, the Norwegian public broadcaster NRK asks users to pass a quiz related to the content of the article before being allowed to comment (Grut, 2017). This innovative approach encourages commenters to have a comprehensive understanding of the article's content, thereby discouraging the dissemination of low-quality comments that could distort the fidelity of the news.

2.2. The Korean context

In Korea, online news consumption is portal centered. News companies' homepages account for only 5% of news distribution, but the share of internet portal sites is the highest in the world (Kim, 2018). Naver, the leading private internet portal in Korea, utilizes an in-link system to display diverse news companies' articles and allows people to leave comments. It has a 66.3% share of news distribution (Newman et al., 2017).

Naver allows users to select news articles from various media outlets on diverse topics, such as politics, society, economics, and entertainment. Users can prioritize their preferred media outlets, and the placement of articles on the screen is determined by personalized features (user preferences), nonpersonalized features (news quality, importance, popularity, etc.), and other algorithms (Naver News). Clicking on a news article not only provides access to the news content but also reveals how many people have reacted to and engaged with the news. Users can check various metrics, including recommendations, emotional expressions (such as great, heartwarming, sad, and angry), and the desire for follow-up articles. In the comments section, news users actively engage in discussions by leaving comments or nested comments or by expressing their agreement or disagreement with others' comments by clicking the like or dislike buttons (see Fig. 1). Approximately 61% of online news consumers in Korea indicate they read article comments (Korea Press Foundation, 2021). Another report observed that 27% of individuals exhibit heightened interest in comments, often pursuing them before delving into the news articles themselves (Hankook Research, 2022).

Originally, information related to commenters was limited to the platform ID and their gender and age distribution, as seen in Fig. 1 b.[2] With news consumption being concentrated through web portals and the recurring manifestation of comment-related matters as significant societal concerns, Naver introduced a new feature in 2020. Now, the platform discloses the history of individual commenters' activities, revealing what comments they have posted and when they posted them (see Fig. 2).

This revision aimed to prevent abusive behavior and create a more constructive public discourse space (Garland et al., 2022). Commenters are encouraged to post with caution, and they are aware their activity is recorded in their profiles. Readers can see the history of commenters' activities, which enables them to critically evaluate or screen those opinions.

2.3. Online public attitudes toward energy transition

Public attitudes are often captured by conducting surveys (see, for example Chung and Kim, 2018; Clarke and Evensen, 2023; Delshad and Raymond, 2013; Kardooni et al., 2018). Recently, social media data have been used to understand the public's perception of energy issues or technologies (see, for example Borch et al., 2020; Liang et al., 2021; Loureiro and Alló, 2020; Mastroeni et al., 2023; Nuortimo and Härkönen, 2018).

Social networking services (SNSs) have been used to capture public attitudes toward specific energy technologies. For example, Loureiro and Alló (2020) used Twitter (now, X) data to analyze public attitudes and sentiments about energy technologies in the U.K. and Spain. Individuals in both countries were found to be generally positive about renewables but negative about coal. More Spaniards had a negative sentiment about nuclear power than British. Borch et al. (2020) analyzed Facebook wind project protest pages and induced Facebook's role as a venue where the public could express various concerns and communicate with neighbors under similar challenges. However, the use of those SNSs to capture the general public's attitude or perception is now challenged and questioned. Younger generations no longer use services such as Facebook or Twitter (Sheldon et al., 2021). In this context, exploring an online news platform as an agora could be a good way to capture public attitudes or perceptions about energy-relevant agendas.

Not everyone actively expresses their attitudes online. A very small number of users account for a large proportion of discussions on online platforms. Mastroeni et al. (2023) found that debates about wind power on Twitter are led by a handful of users who are reposted. The strongest influencer was a climate activist; they were followed by international and government agencies. Online platforms not only collect online news articles and deliver them to the public but also allow the public to express their opinions and participate in debates regarding the news articles by leaving comments and nested comments on relevant news. The accessibility and affordability of online news attracts more and more readers (Korea Press Foundation, 2021; Nelson and Lei, 2018).

A handful of studies have investigated the characteristics of commenters on news websites. However, due to insufficient accessibility to data, commenter characteristics have been analyzed using additional data collected through costly and time-consuming approaches such as interviews (Erjavec and Kovačič, 2012) or surveys (Kalogeropoulos et al., 2017; Van Duyn et al., 2019). Erjavec and Kovačič (2012) conducted in-depth interviews with 20 commenters who wrote hate speech on online news in addition to conducting discourse analysis of comments on more than 350 news articles. Kalogeropoulos et al. (2017) used online survey data from Reuters Institute to analyze the characteristics of online news platform participants who share or leave comments on the news. They found that the individuals who communicated through online news were those who used SNSs for news or SNS platforms, had a clear political orientation, and had a stronger interest in hard news (such as economic or political topics). Some recent approaches (e.g., Lee and Ryu, 2019) have analyzed online news comments with machine learning approaches to understand the characteristics of the users, but these were limited to demographic information about commenters.

The attitudes of the media and public have been explored with separately collected datasets. The characteristics of the public have been explored with additional interviews or surveys. Now that Naver requires users to log in to leave comments on online news, the historical activities of commenters are accessible. This allowed us to obtain the characteristics of commenters, which had been very hard to capture, as described in Erjavec and Kovačič (2012). Our study analyzes commenters' attitudes toward energy transition and looks into their past activities to learn their emotions about other news topics.

3. Methodology[3]

3.1. Data collection

This study used the keyword "energy transition" to collect data from 11,000 internet news articles posted from July 2021 to July 2022 on Naver, the largest internet platform in Korea—61% of Koreans visit it for news at least once per week (Newman et al., 2023). During this period, Korean energy policies radically shifted following a change in national leadership. The former administration's energy policy was actively discussed. From the full set of news articles, 255 were selected based on relevance and meeting a threshold of over 100 comments. Many news articles that included "energy transition" within the headline or main body were irrelevant to the energy policy of the Moon administration. For example, articles discussing the prospects of stocks that could benefit from the implementation of the policy were excluded.

Table 1 specifies the collected data, which included the profiles and

[2] While Naver discloses the summary statistics of users' gender and age, it does not disclose relevant information about individual users.

[3] All data and codes used in this research can be found at the following GitHub link: https://github.com/ByungjunKim/EnergyTransitionKorea.

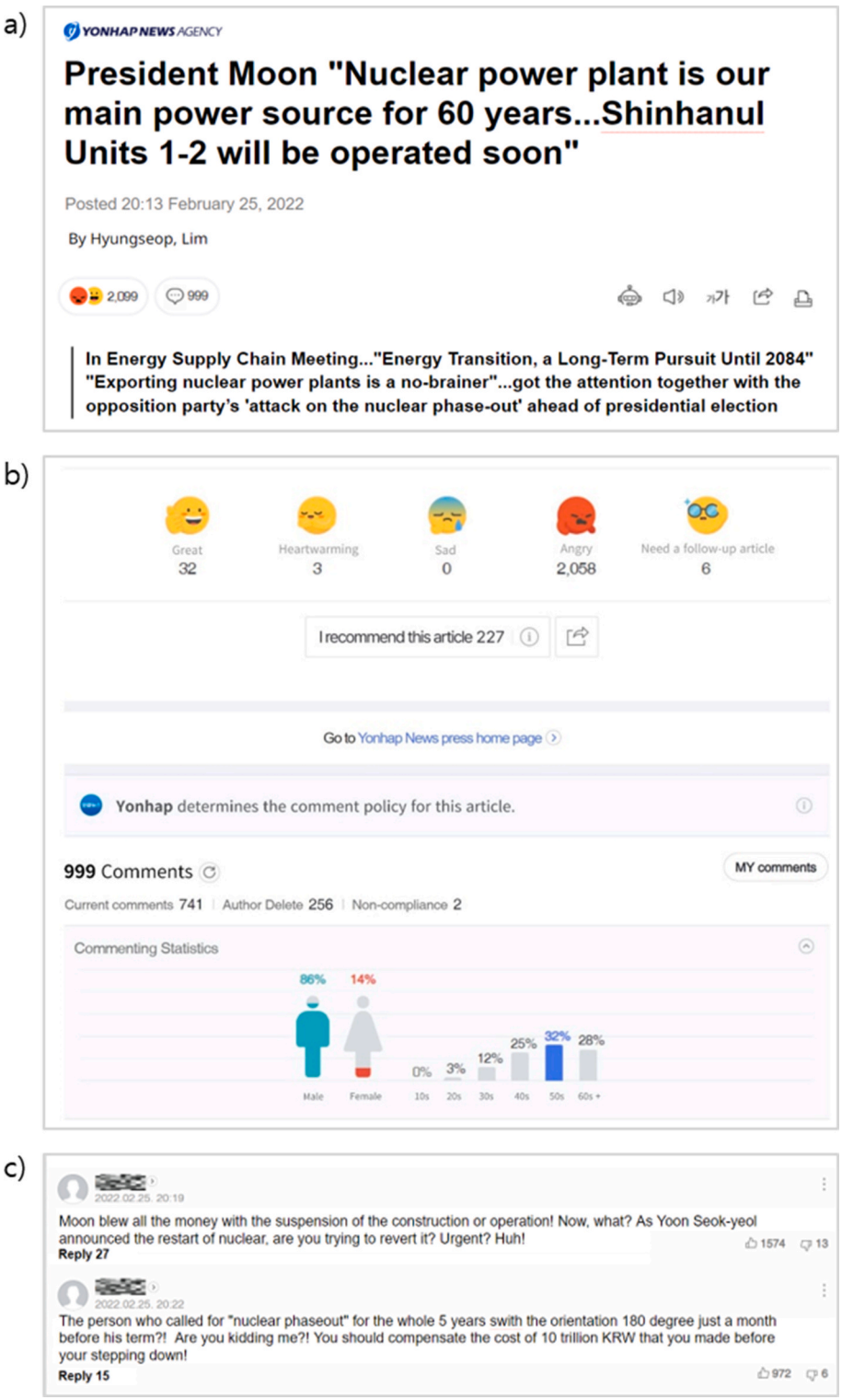

Fig. 1. The layout and embedded functions the Naver news platform uses to promote user engagement. Panel a shows a news headline section, Panel b presents a summary of emotions and commenters at the top of the comment section, and Panel c shows two sample comments. *Note:* The authors translated the sample news and relevant comments into English. The commenters' IDs have been blurred.

comment history of users who provided comments on the energy transition news articles. We gathered up to 5000 historical comments per user. Because Naver does not disclose the gender or age of individual users, the collected data did not include that information.

3.2. Data modeling and analysis

Diverse approaches, ranging from human labeling to machine learning algorithms, allowed us to capture the media and online news platform users' evaluation of energy transition and decode the influences of features on the commenters' emotions and activities. Fig. 3 illustrates the research process.

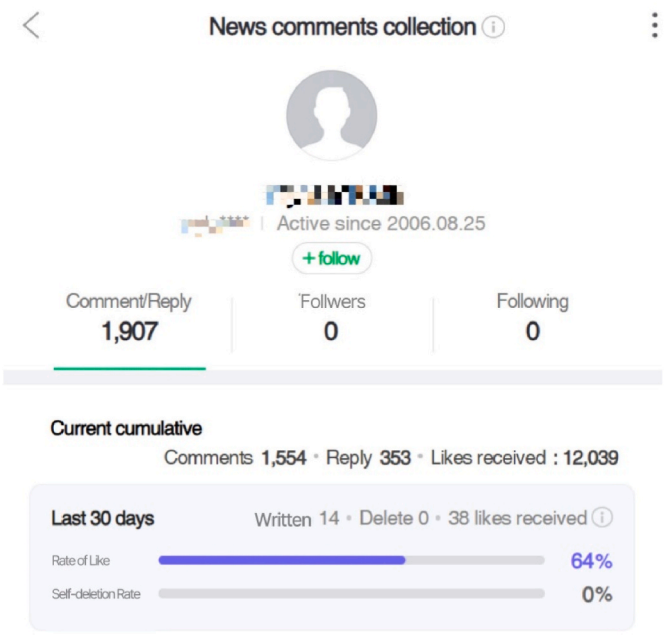

Fig. 2. The history of a commenter. *Note:* The authors translated the sample news and relevant comments into English. The commenters' IDs have been blurred.

Table 1
Specifications of the collected variables.

Index	Variable	Description	Category
1	title	News article headline	news
2	date	News article generation date	news
3	n_reply	Number of comments on the news	news
4	reply	News comment text	reply
5	reply_user_id	User ID of the commenter	reply
6	reply_date	Comment date	reply
7	start_date	Date the user joined Naver	user profile
8	sum_reply	Number of comments from the date of signup to the date of data collection	user profile
9	sum_son_reply	Number of replies to the comments from the date of signup to the date of data collection	user profile
10	sum_emotion	Number of likes and dislikes received from the date of signup to the date of data collection	user profile
11	recent_n_reply	Number of comments made in the last 30 days as of the data collection date	user profile
12	recent_n_emotion	Number of likes and dislikes received in the 30 days before the data collection date	user profile
13	reply_past	User's past comments on the data collection date	user reply history
14	reply_past_date	User's past comments before the data collection date	user reply history
15	reply_past_title	News article headlines of the user's past comments until the data collection date	user reply history

3.2.1. Evaluating tones of news headlines

During the presidential election period, news headlines regarding the energy transition were sensationalized as the incumbent administration's policy agenda was evaluated and criticized. These headlines were often different from the text to attract more readers, but we only coded the headlines because they would be most salient to users. Thus, we manually labeled the tone of news headlines as positive, neutral, or negative, regardless of whether they focused on the former administration's policy or the newly elected one's. We separately labeled the headline's tone toward the direction of Moon's administration's energy transition policy. Three experts in energy policies with more than 10 years of experience labeled these news headlines ('title_p/n' and 'e_policy_p/n'). The results were cross-checked, and inconsistencies were deliberated upon until consensus was reached.

3.2.2. Clustering of users

K-means clustering is a widely used unsupervised machine learning technique employed for analyzing data and identifying patterns. K-means clustering[4] analysis was conducted on the profile variables of a sample of 37,389 people who actively commented on articles related to energy transition. Table 2 presents the findings of the clustering analysis, which involved categorizing users into two distinct categories based on four variables (the total number of comments, the total number of nested replies, the number of comments in the previous month, and the days of membership in Naver) extracted from the users' profile pages provided by Naver. The category of heavy users had higher levels of activity across all four features. They had been active for a longer time and were active in recent months. The mean of the total number of comments they left during their membership was approximately five times that of normal users. The variable "user type" was derived for subsequent data analysis.

3.2.3. Tokenizing

We used token count and type token ratio (TTR) to evaluate 53,707 comments on energy transition news articles and 55,194,663 historical user comments. In natural language processing, a token typically segments a sentence. Here, *token* denotes a morpheme, specifically a Korean morpheme, excluding special characters, hashtags, emojis, etc. We employed the Korean Morphology Analyzer (Kiwi)[5] to identify morphemes. TTR, a measure of lexical diversity (Richards, 1987), is the ratio of unique tokens to total tokens. A TTR closer to 1 suggests greater lexical diversity. We analyzed token counts and TTRs for energy transition comments and historical comments (see Table 3).

3.2.4. Classifying comments and the news based on deep learning

We used a deep learning model to analyze factors like users' comments and article headlines. Emotion classification allows the classification of a broader emotional range than sentiment analysis. GoEmotions by Google (Demszky et al., 2020) is a notable tool for this, but it only supports English. We employed Korean Online That-gul Emotions (KOTE), a Korean version of GoEmotions (Jeon et al., 2022). Given KOTE's extensive 44-emotion classification, we adopted KOME (Korean Online Moral Emotion)[6] (Kim et al., 2023), which simplifies emotion classification into six categories from KOTE's datasets, based on Haidt's moral emotion theory (Haidt, 2003).

This study focused on four of the six emotions provided by KOME (condemning, praising, suffering, and conscientious). We excluded neutral and nonmoral emotions, as they were deemed insignificant for our research based on the initial learning trials (see Table 4). These emotions were coded as values between 0 and 1, with values closer to 1 indicating higher probability that the user comments are likely to convey the relevant emotion (e.g., condemning).

We utilized a natural language model to classify article headlines by topic. KPF-BERT-CLS,[7] a bidirectional encoder representations from transformers (BERT) model developed by the Korea Press Foundation, has been trained on approximately 40 million Korean news articles, making it more apt for news than models based on wikis or social media.

[4] The KMeans function from the scikit-learn library was employed: https://scikit-learn.org/stable/modules/generated/sklearn.cluster.KMeans.html.
[5] https://github.com/bab2min/kiwipiepy.
[6] The classification model performance of KOME is 0.7, as measured by the F1-score. The checkpoint file associated with the model can be obtained at https://huggingface.co/kjhkjh95/KOME.
[7] The checkpoint file is available for download at https://huggingface.co/KPF/KPF-bert-cls1.

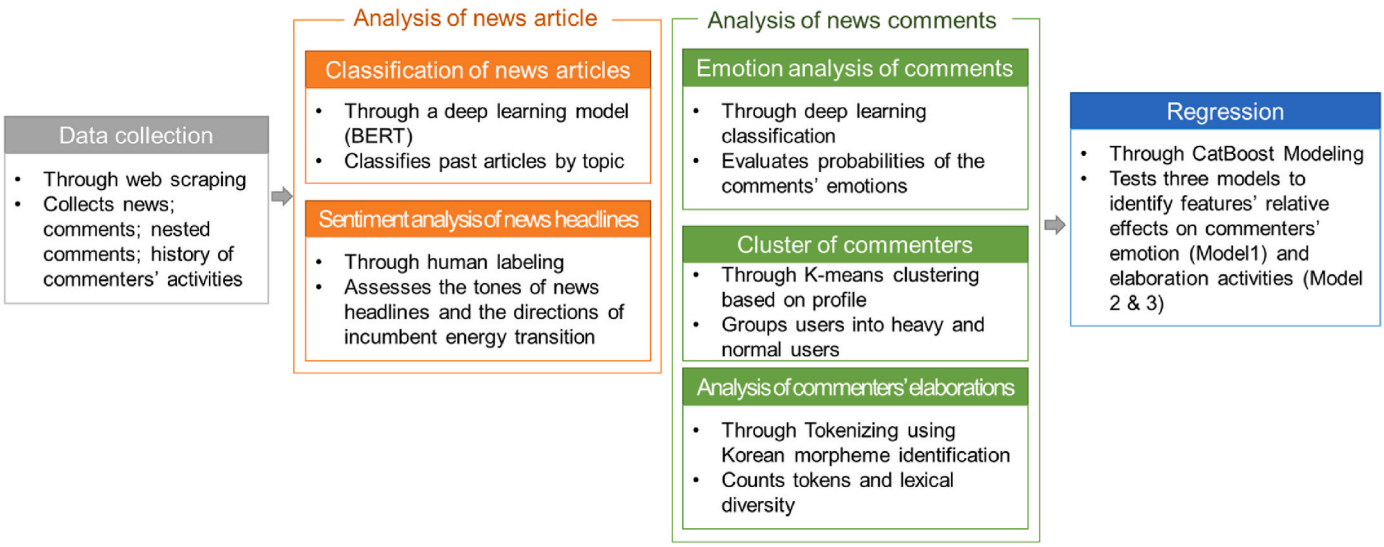

Fig. 3. The research process.

Table 2
Descriptive statistics of heavy and normal users' activities.

User type	Variable	Mean	Median	Std. dev.	Min	Max
Heavy user	Total number of comments	10,051.9	9,033.5	5,675.6	153	50,725
	Total number of nested replies	2,505.1	1,512	3,511.6	0	64,071
	Number of comments in the previous month	251.4	228	159	0	1,371
	Number of days the user had been a member of Naver	4,411.9	4,164.5	1,682.5	446	6,366
Normal user	Total number of comments	2,103.8	1,468	2,023.3	1	14,358
	Total number of nested replies	331.8	122	533.5	0	7,313
	Number of comments in the previous month	45.6	22	57.2	0	396
	Number of days the user had been a member of Naver	3,653.4	3,514	1,762.3	408	6,366

This model classifies news into seven categories: politics, economy, society, international affairs, culture, IT & science, and sports. Like emotion classification, values between 0 and 1 indicate the probability that the news falls into a category.

3.2.5. *Decoding factors influencing users' emotions and elaborations*

We utilized the CatBoost algorithm to investigate the impact of various features on the users' emotions and elaborations in comments. Given the significant presence of categorical variables identified through human labeling, CatBoost was the optimal choice. This gradient-boosting machine learning algorithm is renowned for its native handling of categorical data (Prokhorenkova et al., 2018), efficiency with categorical variables, fast learning rate, and superior prediction accuracy. The derivative variables that we had created were incorporated as both input and output variables in our model.

4. Results

4.1. *Exploratory data analysis*

Fig. 4 shows the emotion classification of comments on news related to energy transition. Most comments had a marked bias toward condemnation, with other emotions having less importance. This indicates news commenters express anger more often than other emotions.

We explored significant differences in the condemning emotion by considering user types, the tones of news headlines, and the media's evaluation of the former administration's energy transition. Given that the condemning emotion was not normally distributed, we employed nonparametric statistical tests. Using the Mann-Whitney *U* test, no significant difference was found between heavy users and normal users ($p = .3085$).

The tones of news headlines ('title_p/n') and the media's evaluation of the energy transition ('e_policy_p/n') were placed into three categories (positive, negative, and neutral). Applying the Kruskal-Wallis H test, we found a significant difference in the condemning emotion among different tones of headlines ($p < .0001$). A post hoc test (Tukey's HSD) revealed a significant difference in the mean value of condemning between any possible pairs ($p < .001$). The emotion did not display any difference based on the evaluation of energy transition ($p = .4214$). To gain an initial understanding of the comment content, we extracted the nouns and examined the most frequent keywords. The top 10 words for both unigrams and bigrams are presented in Table 5. Although Naver adopted an AI called Cleanbot in 2019 to filter and hide comments that

Table 3
Descriptive statistics of the number of tokens and TTR.

Type	Variable	Mean	Median	Std	Min	Max
Comments on energy transition news articles	Number of tokens	32.1	22	31	1	218
	TTR	.91	.93	.10	.026	1.0
Historical comments of all users	Number of tokens	28.8	20	27.5	0	2,428
	TTR	.91	.94	.10	0	1.0

Table 4
Moral emotion classifications and relevant emotions.

Moral emotion	Relevant emotions under moral emotion
Condemning	Anger, contempt, disgust
Praising	Admiration, gratitude
Suffering	Compassion
Conscientious	Shame, guilt, embarrassment

Source: Adapted from (Kim et al., 2023, Table 2.)

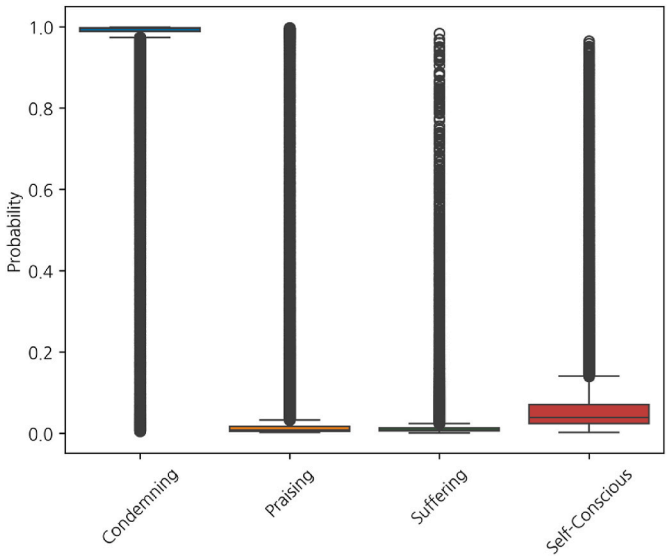

Fig. 4. Emotion classification of comments on energy transition news.

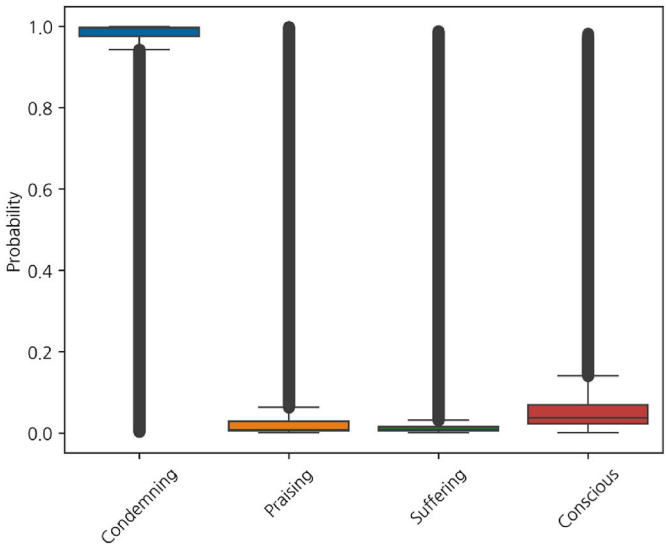

Fig. 5. Emotion classification of past comments.

included inappropriate language, such as profanity (Kim, 2019), commenters expressed their intense emotions through the subtle modification of words. Two primary themes emerged from these keywords. First, there was a cluster of political terms associated with President Moon and his administration. Second, terms related to energy transition, such as "solar" and "renewable energy," were prominent. The prevalence of these keywords suggests that the topic of energy transition is deeply entwined with Korean political discourse.

The emotion classification of users' past comments also revealed a pronounced concentration in the condemning emotion (see Fig. 5). With a mean of 0.91 (a standard deviation of 0.23), condemning dominates the emotional landscape of past comments, rendering the presence of other emotions almost negligible.

Among the headlines of articles users previously commented on using the KPF-BERT-CLS model, politics and social issues were the most prevalent topics, indicating the users had the most interest in those issues (see Fig. 6). While international issues also garnered significant interest, this might be attributed to a temporary dramatic increase in news volume during the COVID-19 pandemic.

Table 5
Words frequently occurring in comments.

Rank	Unigram	Frequency	Bigram	Frequency
1	Wonjeon (Nuclear power plant)	19,573	Moon_Jaeang (Derogatory term for President Moon Jae-in)	1,650
2	*Nara* (A state)	5,206	Jaesaeng_Eneoji (Renewable energy)	971
3	Gungmin (People)	5,158	Tanjung (Carbon neutrality)	730
4	*Taeyanggwang* (Solar PV)	4,452	Jeongi_Yogeum (Electricity rates)	728
5	*Mal* (End of (term))	4,439	Jeonggwon_Gyoche (Regime change)	586
6	*Moon Jae-in* (Moon Jae-in)	3,889	Moon_Joein (Derogatory term for President Moon Jae-in)	580
7	Jeongi (Electricity)	3,801	Taeyanggwang _Paeneol (Solar PV panels)	548
8	Jeonggwon (Regime)	3,471	Taeyanggwang _pungnyeok (Solar wind)	449
9	*Moon* (Moon Jae-in)	3,456	Dae_Gang (Great river)	409
10	Daetongnyeong (President)	3,310	Segye_Choego (World's best)	332

Note. Korean words are Romanized according to their pronunciation.

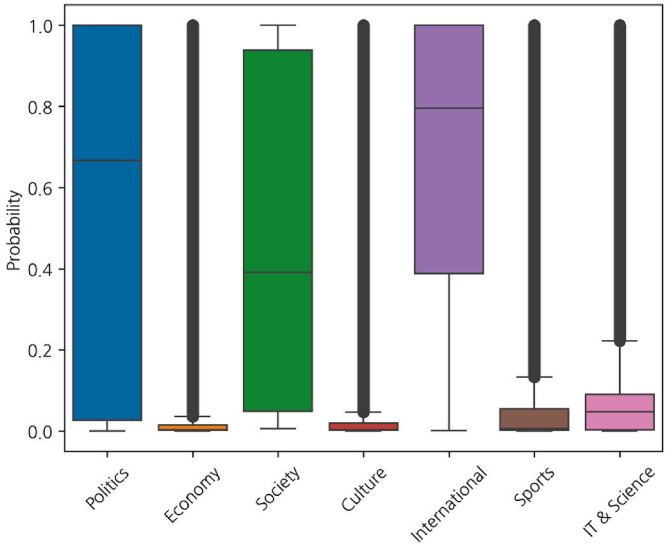

Fig. 6. Boxplot of the news topics for which users left comments.

4.2. Modeling and interpretation of user responses to energy transition news

We used the Catboost regressor to test three models that captured the effect of user features on their emotions and elaboration levels when they left comments. This approach enhanced our understanding of the commenters who left opinions on energy transition news articles. Model 1 predicts the commenters' condemning emotion on energy transition news using 16 input features: user-related variables (three), tone of news headlines (two), news categories users commented on in the past (seven), and median values of the emotions of users' past comments (four). Models 2 and 3 predict elaboration by the users, focusing on the length of comments (Model 2) and the diversity of words used (Model 3). We interpreted the results of the CatBoost algorithm using Shapley additive explanations (SHAP).[8] SHAP provides a coherent and unified measure of feature importance, making it valuable for understanding model predictions. In Table 6, the top three features with a positive relationship are marked with (+), while those with a negative

[8] https://github.com/shap/shap.

Table 6
Summary of models and their variables.

	Model 1	Model 2	Model 3
Dependent variable	Condemning	Number of tokens	TTR
Independent variable			
User-related variables (3)	user_type, (median) tokens_len_past, (median) ttr_past		
Tones of news headlines (2)	title_p/n, e_policy_p/n		
The news categories users have commented on in the past (7)	politics, economy, society, culture, international, sports, IT_science		
Median emotion of users' past comments (4)	condemning_past, praising_past, suffering_past, self-conscious_past		
Top 3 features	condemning_past (+), praising_past (−), title_positive (−)	tokens_len_past (+), ttr_past (−), e_policy_negative (−), e_policy_neutral (+), e_policy_positive (+)	ttr_past (+), tokens_len_past (−), e_policy_negative (+), e_policy_neutral (−), e_policy_positive (−)
R^2	.082	.346	.245
Adjusted R^2	.080	.345	.244
MAPE	1.033	1.098	.085
Normalized MAE	.088	.085	.075
CV-RMSE	.189	.783	.097

relationship are indicated with (−).

In Model 1, past emotions, whether negative ('condemning_past') or positive ('praising_past'), and the tone of news ('title_positive') had the largest impact (see Fig. 7). Previous condemning emotions beyond energy transition news during the election period had a high positive impact on the current emotion of condemning. In contrast, past praising emotions were negatively correlated with current condemning emotions. This indicates that individuals revealing attitudes against energy transition issues have a stubborn negative emotion regardless of news topics or categories.

The media mostly portrayed the energy transition negatively. Most attitudes about energy transition policy revealed in the headlines had a negative tone: 67.7% of news headlines were negative, and 58.0% of them framed energy transition policies negatively.

A meaningful association between media framing and the level of emotions of the public was identified. We found that the media's positive framing of energy transition appeases users' intense condemning emotions. When the media positively framed the headline, the condemning emotion was significantly lower (mean = 0.910, std. dev. = 0.230) than when it provided a negative framing (mean = 0.944, std. dev. = 0.171), as shown on the Kruskal-Wallis H test and Tukey's HSD test and confirmed by Catboost regression.

Comment length has been investigated as a measure of deliberativeness in comments (Beckert and Ziegele, 2020; Borge et al., 2019). Because length has limitations, such as not capturing the qualitative contribution (Manosevitch et al., 2014), this study used the diversity of the tokens (TTR) used in comments as another aspect of elaboration.

Models 2 and 3 indicated that the commenters' propensity to elaborate on their opinions on energy transition news articles by making longer comments ('number of tokens') or using more diverse words ('TTR') was influenced most by their past level of elaboration—'tokens_len_past' and 'ttr_past' for Model 2 (Fig. 8). This means that users who wrote longer comments on other topics in the past left longer comments on energy transition news as well.

In Model 2, however, the diversity of the words used in the past ('ttr_past') was negatively correlated with their length ('number of tokens'). This tradeoff is a natural consequence of the diversity of words ('TTR') being calculated by using total tokens as the denominator. In addition, whether the headline framed energy transition issues positively or negatively influenced the elaboration level. When the headline positively or neutrally framed the incumbent's energy transition policies, the comments were longer. In contrast, a negative framing had shorter comments.

The diversity in words used to leave comments on news in the past ('ttr_past'), the length of comments left in the past ('tokens_len_past'), and the media's evaluation of the incumbent's energy policies in headlines ('e_policy_p/n') had the highest effect on the current elaboration level in comments on energy transition-relevant news ('TTR'), as shown in Fig. 9. As in the Model 2 results, people who used more diverse words in the past tended to use more diverse words to express their attitudes about energy transition. The tradeoff between the diversity of words used and the comment length was found as well: 'TTR' was negatively correlated with 'tokens_len_past'. The effect of news framing in Model 3 contrasted with Model 2. When media negatively evaluated the energy transition policy, users tended to use more diverse words.

5. Discussion

This study investigated public opinion about Korean energy transition policies by collecting and analyzing relevant online news and comments. It covered a period of government transition, during which the outgoing administration focused on phasing out both nuclear and coal in favor of expanding renewable energy and the incoming one focused on retaining a larger role for nuclear energy. Online comments were filled with animosity to energy transition—the dominant moral emotion was condemning—but this intense negative emotion was also prevalent in users' past comments on diverse topics. This calls into question the idea that online comments capture public perceptions of and attitude toward this or any agenda. Commenters on energy policy articles could be characterized as a raging political crowd who focuses on political and social issues. We also found that incivility has continued, even with efforts to mitigate the impact of anonymity and foster a space for constructive dialogue through revealing the past records of commenters.

There was an initial expectation that rational, critical discourse about political and social issues would occur in online spaces like the comment section of online news articles (see Dahlberg, 2001). Instead, comment sections have turned out to be a contentious space pervaded by incivility and intolerance (Rossini, 2020). Our study supports Stroud et al.'s (2016) idea that online news comment sections are used to express intense emotions rather than to engage in mature deliberation. The presence of anger in a news comment section can be accentuated by the interplay between the topic and the features of the platforms. According to Oz et al. (2018), when a platform deindividuates by becoming more anonymous, users tend to be more uncivil and impolite and less deliberative in their political talk. In that study, incivility was heightened in comments about controversial issues like same-sex marriage and gun control, just as we found to be the case for the Korean energy transition.

Our observations reveal that energy policy news often catalyzes political blame, mockery, and conflicts. When a society experiences large-scale rapid change, existing policy faces reevaluation or intensified criticism (Lucas, 2017). Energy policy and debates over renewables and nuclear power have been political issues in Korea (Chung and Kim, 2018). During the change in government, the energy transition policy of the former administration was criticized because there were contrasting perspectives on renewables and nuclear power. The nature of these two technologies—modular vs. large scale, distributed vs. centralized, intermittent vs. continuous—has led to the choice being framed like a

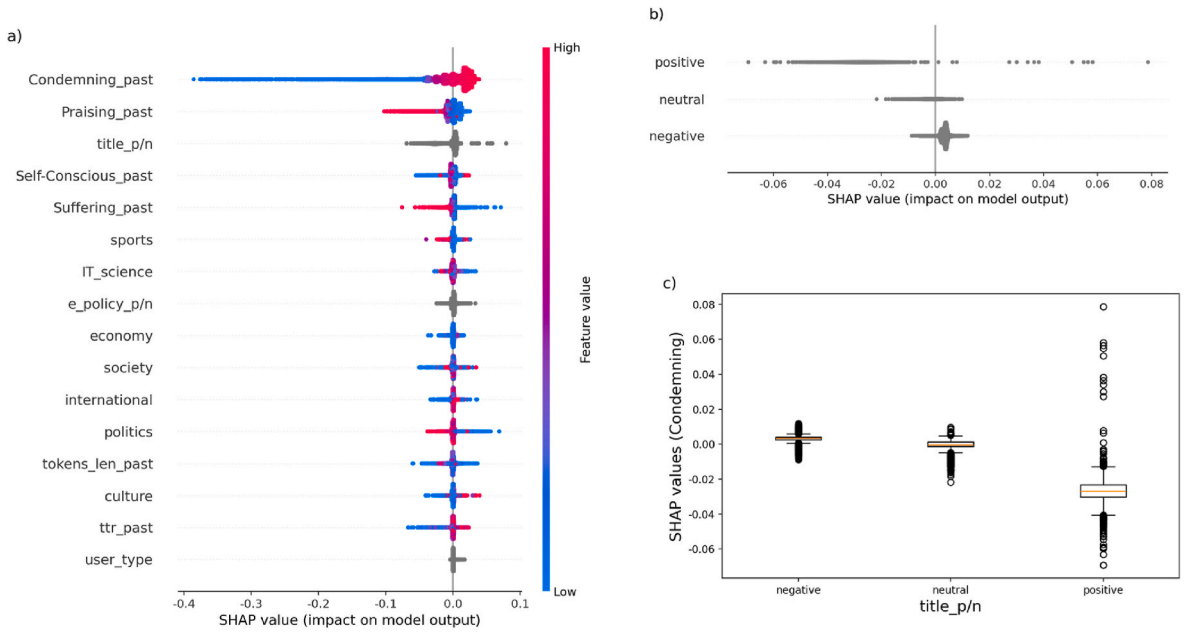

Fig. 7. Current condemning emotion prediction model. Panel a shows SHAP summary plots displaying the influence of each feature on the model's predictions. Features are ranked by importance on the y axis, while the SHAP value is on the x axis. Each dot represents a feature's SHAP value, with its color indicating high (pink) or low (blue) feature values. Gray dots indicate categorical or missing data. Panel b illustrates the impact of each level (positive, neutral, negative) of the nominal variable 'title_p/n' on condemning, with the x axis representing the SHAP value. Panel c presents a boxplot based on Panel b, where the y axis shows the SHAP value. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

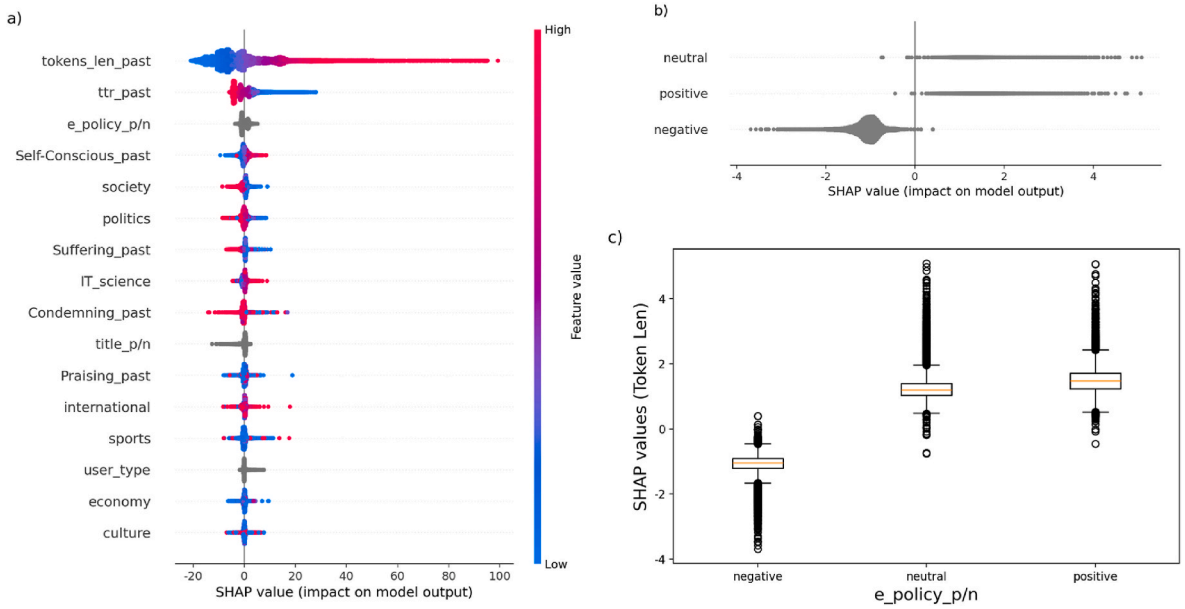

Fig. 8. Current comments elaboration prediction model. Panel a shows SHAP summary plots displaying the influence of each feature on the model's predictions. Features are ranked by importance on the y axis, while the SHAP value is on the x axis. Each dot represents a feature's SHAP value, with its color indicating high (pink) or low (blue) feature values. Gray dots indicate categorical or missing data. Panel b illustrates the impact of each level (positive, neutral, negative) of the nominal variable 'e_policy_p/n' on condemning, with the x axis representing the SHAP value. Panel c presents a boxplot based on Panel b, where the y-axis shows the SHAP value. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

war. If renewable energy were expanded, that would harm a nuclear industry that Koreans have perceived as the essence of scientific advancement and the source of economic competitiveness (Choi et al., 2009; Park, 2022).

Another pivotal research finding emerges from how news framing affects the deliberative characteristics of comments. Through human labeling of the tone of news headlines and their evaluation of energy transition policies, we discovered that the valence of the frames significantly influenced the intensity of condemnation expressed in comments (i.e., negative frames led to more negative emotions and opinions). This underscores the profound impact of news framing on public opinion (Druckman and Nelson, 2003; Gross, 2008; Valkenburg et al., 1999), particularly in terms of emotional reactions (Kim and Cameron, 2011; Lecheler et al., 2013; Myers et al., 2012). Given that news frames offer a specific interpretation of issues and emphasize certain aspects of them, a negative tone in the news can trigger negative

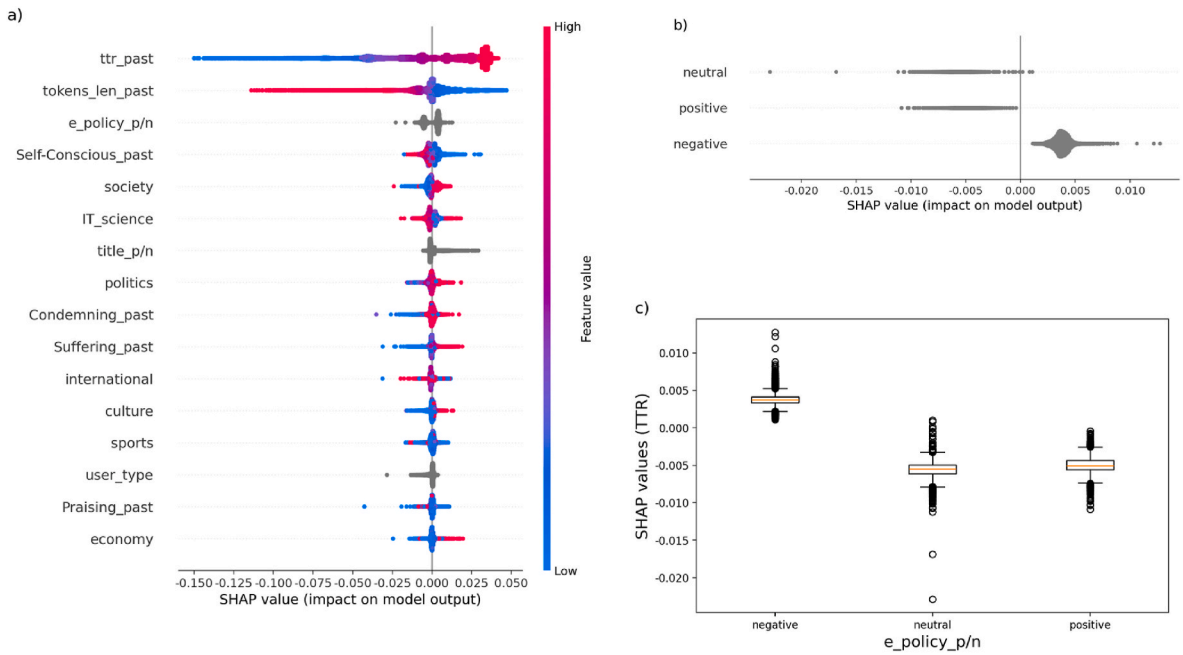

Fig. 9. Current comments elaboration prediction model. Panel a shows SHAP summary plots displaying the influence of each feature on the model's predictions. Features are ranked by importance on the y axis, with the SHAP value on the x axis. Each dot represents a feature's SHAP value, with its color indicating high (pink) or low (blue) feature values. Gray dots indicate categorical or missing data. Panel b illustrates the impact of each level (positive, neutral, negative) of the nominal variable 'e_policy_p/n' on condemning, with the x axis representing the SHAP value. Panel c presents a boxplot based on Panel b, where the y axis shows the SHAP value. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

emotions, such as anger.

On the other hand, our observations reveal that news frames can elicit thoughtful and well-elaborated opinions in the context of controversial discourse. When the framing was not negative, comments tended to be longer, indicating more nuanced and elaborated opinions. Consequently, such framing can foster discussions that are less characterized by anger and more conducive to thoughtful engagement about energy transition. This aligns with several studies that have shown citizens rely on frames as resources in political conversations (Brewer and Gross, 2005; Gamson and Modigliani, 1989).

This study contributes to the literature in two ways. First, by collecting and analyzing users' past comments, it captured the prevalence of negative emotion in comments on diverse topics beyond energy transition policy. The online news platform was used as a space where users vented their emotions rather than as an agora for deliberation. This suggests being cautious about studies that use news comments to capture public attitudes or perceptions about a specific agenda. Second, by associating sentiments revealed in the tone of news headlines with the emotions captured in comments, it showed that media framing could lead to more constructive deliberation on online news platforms. Neither of these findings could have been identified by analyzing only the comments on news articles related to energy transition.

6. Conclusion and policy implications

This study has enriched the literature on media framing and public sentiment toward energy transition issues by developing and analyzing a novel dataset comprising online news headlines, pertinent news comments, and the commenters' historical activities on a prominent Korean online news platform, Naver. Our approach leveraged advanced diverse cutting-edge machine learning methods such as K-means clustering, text classification, and Catboost regression.

We believe this is the first time a single dataset has included both comments and the historical activities of commenters. Our diverse methods allowed us to find that the condemning emotion was dominant in general, not only with respect to energy transition policies. The commenters are a raging political crowd who express intense negative emotions on social and political issues. This suggests being cautious when interpreting the emotion captured in comments relating to energy policy topics without further investigation of users' historical activities. This study also suggests news framing could promote deliberation by relieving the intensity of emotions and enhancing users' deliberation. Above all, this study highlights the need to understand the nature of the public in online spaces before exploring their emotions or sentiment toward a certain agenda. It is important to analyze comprehensive datasets using diverse methods to overcome the limitations of using a single method or type of data.

We draw three policy implications. First, the findings imply that reviewing news comments is no substitute for a survey based on representative sampling and well-structured questionnaires. However, this does not mean it is useless to decipher news comments. Most Korean people consume news on mobile phones through the online news aggregator Naver, which collects and records users' opinions on various topics. The Korean government can use news comments to capture the public's concerns or complaints about energy transition, but it should not believe the emotions expressed in the news comments reflect the general public's perception of the agenda. Second, platforms should discourage uncivil news comments in order to encourage users' deliberativeness, even though their efforts so far have not had the expected outcomes. Technological enhancement, regulations, and institutional support should be used to expedite and encourage further changes. For example, innovative functions like providing a news summary using a small pop-up window when people begin commenting could be introduced. Third, headlines should convey the message accurately and neutrally. Although the government cannot mandate this, it would shape the atmosphere so this near-monopoly online news aggregator can try to be a mature and civil platform—an agora.

Although the past comments of the users and our diverse methodologies have enhanced understanding of users' emotions and elaborations, this approach has some limitations for understanding what drives the intense emotions against energy transition. Additional analysis may be needed to refine the words, such as by excluding derogatory

expressions against a person. This warrants future study.

CRediT authorship contribution statement

Byungjun Kim: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Soeun Yang:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Hana Kim:** Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Hana Kim reports financial support was provided by National Research Foundation of Korea. Hana Kim reports financial support was provided by Korea Foundation for the Advancement of Science and Creativity.

Data availability

The anonymized data is accessible through github together with code.

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