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Public discourses and government interventions behind China's ambitious carbon neutrality goal

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Mobilizing the public supports on ambitious climate change goals is crucial for climate action. Here we examine what public discourses have emerged in China around its ambitious carbon neutrality goal and how Chinese government has influenced its public opinion. By using deep learning model to analyze approximately one million microblogs from China, we track the evolution of seven climate discourses among the online public discussing China's carbon neutrality goal, including scientific, moral, economic, co-benefit, energy security, political, and global frames. Among this community, we find a high level of supports towards China's carbon neutrality goal. Opposers cite global and moral concerns as their main reason for opposition and are increasingly internally divided in China. Those who are neutral are more easily influenced by an economic discourse. Major climate policies are more effective than politics to influence public views on carbon neutrality.

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Transitioning to a net-zero world is one of the greatest challenges humankind faces. More than 100 national governments and 800 cities have set or are considering net-zero emissions targets[1]. As the world's largest energy consumer and CO_2 emitter[2], China made a historical promise to peak its emissions before 2030 and achieve carbon neutralization before 2060. Setting a goal is perhaps the easiest step toward carbon neutrality. Public support around collective goals is a precondition for sustainable action[3–5], and implementing costly public policies required to achieve climate and carbon neutrality goals[6].

Public perceptions of climate change have been proven critical in explaining variation in emissions pathways and process of policy making[7–9]. Different from other issues, the public perceptions and attitudes around climate change is especially complicated and challenging to reach consensus due to invisibility of causes, distant impacts of climate change, lack of immediacy, etc[10,11]. Most of existing literature using questionnaire surveys reveals public sensibility and concerns[12,13], individual actions and policy support related to climate change in the United States, China and other countries[14–18]. With the rise of online social media, an increasing amount of research employs online social media data to analyze the dominant topics, network structures and information flows of online climate discussions[19–21]. While the existing literature emphasizes the significance of discourses concerning climate perceptions[22–24], to our best knowledge there is a lack of quantitative research exploring public discourses surrounding the goal of carbon neutrality and how governments efforts can influence public discourses.

To address this gap, this paper delves into the primary public discourses that have emerged in China concerning its carbon neutrality goal, as well as how the Chinese government has influenced public opinion. The study first develops a typology of seven frames and three attitudes (Method and Supplementary Note 1) that the Chinese public takes in its climate change discourses. The study then gathers and employs an active learning approach to train a deep learning model for classifying approximately one million microblogs from China's popular social media platform, Weibo. This model is used to assess the distribution and evolution of public discourses surrounding China's carbon neutrality objective. The study further investigates how the government's policies and political activities shape public views and internal consensus of different attitude communities.

The results reveal a diverse online public community with respect to the discourses surrounding the China's carbon neutrality goals. The study indicates a notable degree of online support, coupled with a limited level of opposition, toward China's carbon neutrality goal. Supporters for carbon neutrality have heterogeneous reasons, whereas opposers take global and moral angles to defend their opposition and the neutrals are most influenced by an economic narrative. We observe that opposers are increasingly divided about climate change within their own communities. The research also finds that policies matter more than politics in shaping public opinions on carbon neutrality in China.

The paper offers three contributions to the existing body of literature. First, it pioneers the exploration of public discourse surrounding China's ambitions for carbon neutrality. This achievement is facilitated through the application of state-of-the-art deep learning techniques and the utilization of extensive data extracted from a prominent Chinese social media platform. Second, different from previous literature, our research identifies different attitude communities within China (including opposers, neutrals, and supporters), and examines their primary concerns underlying China's carbon neutrality goals. Third, this study further explores the impacts of governmental initiatives on the public's perspectives regarding carbon neutrality.

Results

Bird's-eye view of the online public on carbon neutrality. Since China announced its carbon neutrality goal in September of 2020, online carbon neutrality accounts and contents have quadrupled. These contents were further reposted millions of times, indicating a growing and broader community engagement. It is worth noting that the proportion of users actively engaging in discussions related to carbon neutrality constitutes only a marginal portion of all microblog users (0.006%), which aligns with previous studies[25]. Individuals (accounting for 90.06% accounts) dominated climate content creations, creating 75.20% of the posts. Institutions produced less posts but are more influential with higher average reposts (Fig. 1a). The climate-related accounts and posts created by individuals has a marked increase, pointing to the emergence of people as a driving force behind China's carbon neutrality goals (Fig. 1b).

More than 70% of posts express clear support for China's carbon neutrality goal. And blogs endorsing climate change actions are more socially influential; their average reposts are five times higher than opposing blogs (Fig. 1c). Opposing posts have increased, but even so only account for about three percent in total. Compared with institutions, higher ratio of individuals showed opposition against climate change or carbon neutrality. Whereas institutions are stable regarding their attitudes, individuals' attitudes are more instable and volatile over time (Fig. 1d).

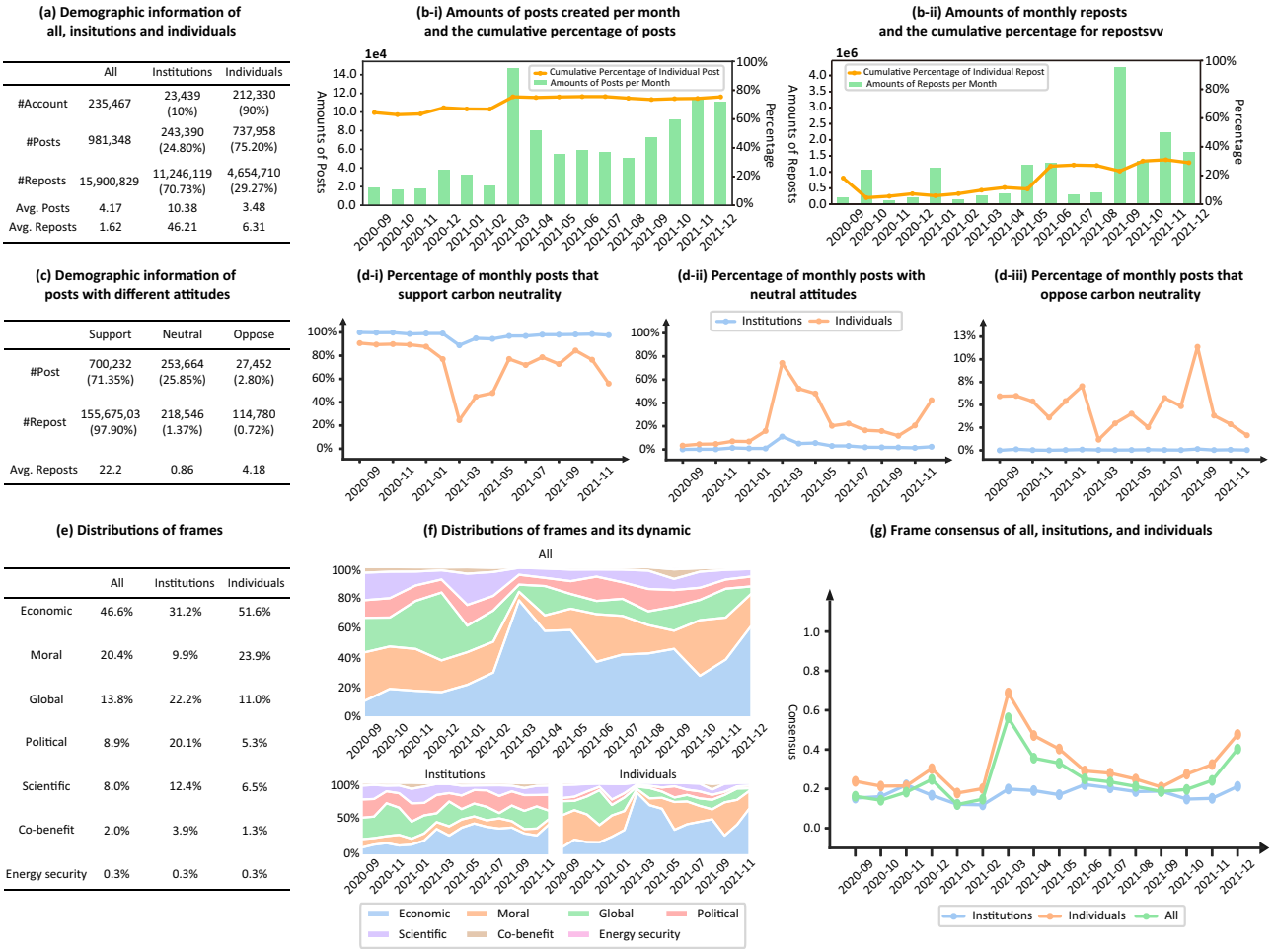
The Chinese public discourses on carbon neutrality are diverse (Fig. 1e). Among the seven frames that the research developed, economic, moral, and global frames were the most popular ones, generating more than 80.8 % of carbon neutrality posts. Unlike western countries[11], energy security and co-benefits are the least used frames in China, accounting for only two percent of total posts.

The study then measures the monthly internal frame consensus among the Chinese online community engaging with discussions on carbon neutrality using the normalized entropy for frames (Details in Method). It shows that a low level of internal frame consensus has been established (Fig. 1f, g). Institutional actors use frames in more even and stable ways. Individuals focus more on economic and moral frames but much less on politics. Though individuals rushed to an economic frame in March 2021, the fanaticism quickly faded, suggesting the instability of this frame among individuals.

Opposers, supporters, and their internal consensus. 59.7% of opposing posts use global and moral frames to question carbon neutrality (Fig. 2a). Global viewers either take the traditional western trap hypothesis to argue that western countries use climate change as an excuse to cap China's development or emphasize the western hypocritical actions on climate change. One example is emphasizing the United States' inconsistencies on climate change actions or repeated retreats from the Paris Climate Change Agreement. The moral angle focuses on the hypocritical behaviors of rich people and celebrities. Compared with the overall population, opposers are more apt to doubt scientific evidence on climate change because their observations of local extreme cold weather contrasts with global warming.

Carbon neutrality supporters take frames more evenly. After March 2021, the neutral actors shift their favorite frames from moral and scientific to an economic frame (Fig. 2b). And, over time, they have the highest internal consensus compared with supporters or opposers and are consistently dominated by the economic frame (Fig. 2c).

An interesting observation is that opposers demonstrate a lower and still significantly declining internal frame consensus during our study period (Fig. 2c). This means that opposers are



	All	Institutions	Individuals
#Account	235,467	23,439 (10%)	212,330 (90%)
#Posts	981,348	243,390 (24.80%)	737,958 (75.20%)
#Reposts	15,900,829	11,246,119 (70.73%)	4,654,710 (29.27%)
Avg. Posts	4.17	10.38	3.48
Avg. Reposts	1.62	46.21	6.31

	Support	Neutral	Oppose
#Post	700,232 (71.35%)	253,664 (25.85%)	27,452 (2.80%)
#Repost	155,675,03 (97.90%)	218,546 (1.37%)	114,780 (0.72%)
Avg. Reposts	22.2	0.86	4.18

	All	Institutions	Individuals
Economic	46.6%	31.2%	51.6%
Moral	20.4%	9.9%	23.9%
Global	13.8%	22.2%	11.0%
Political	8.9%	20.1%	5.3%
Scientific	8.0%	12.4%	6.5%
Co-benefit	2.0%	3.9%	1.3%
Energy security	0.3%	0.3%	0.3%

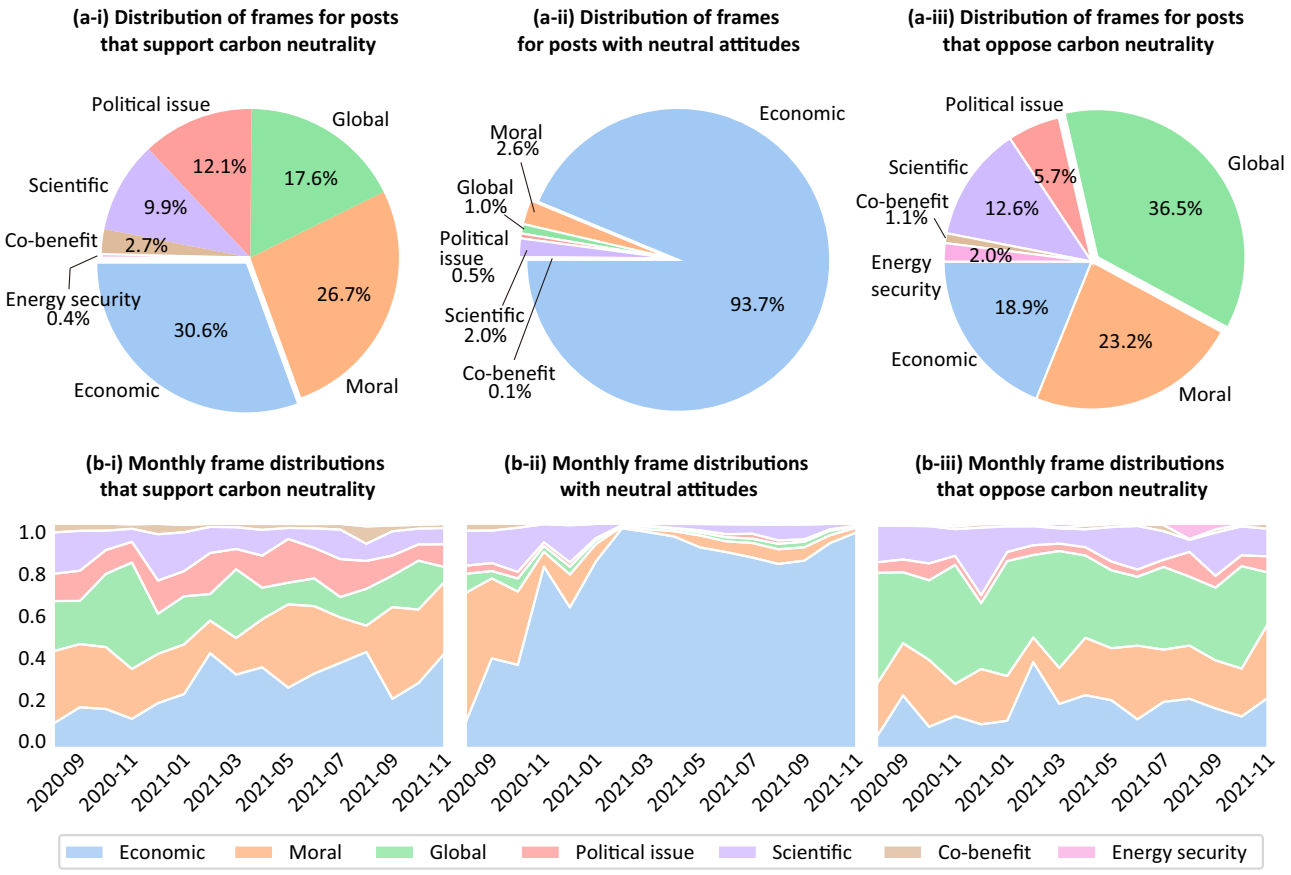
Fig. 1 Bird's-eye view of the community participating in public carbon neutrality on the Weibo platform from Sept 2020 to December 2021. **a** Demographic information of all, institutions and individuals. **b**i Number of posts created per month and the cumulative percentage of posts created by individuals. The green bar represents number of posts per month. The orange line represents cumulative percentage of posts created by individuals. **b**ii Number of monthly reposts and the cumulative percentage of reposts for posts created by individuals. **c** Demographic information of posts with different attitudes. **d** Percentage of monthly posts that (i) support carbon neutrality, (ii) with neutral attitudes, and (iii) oppose carbon neutrality among institutions and individuals. Blue line represents the percentage of posts with different attitudes among institutions. Yellow line represents the percentage of posts with different attitudes among individuals. **e** Distributions of frames. **f** Evolution of frames among all—institutions and individuals. The colorful segments represent shares of different frames over time. **g** Frame consensus of all—institutions, and individuals. The green line represents frame consensus among the whole society, blue line represents frame consensus among institutions, and yellow line refers to that of individuals.

becoming more divided regarding their reasons behind oppositions. Contrary to opposers, the supporters are becoming more aligned with each other regarding their frame preferences, which is indicated by an increasing frame consensus. The growth of the internal frame consensus among supporters is partially due to an increase favor in using an economic frame and a reduction in using the global frame (Fig. 2b).

Top influencers and their strategies. The research examines top influencers that lead climate change discussions in China. Influencers are selected as the top 300 (0.13%) accounts whose carbon neutrality blogs were most reposted. These top influencers created 3.25% of posts but generated 92.26% of reposts. Compared with the overall users engaging in carbon neutrality discussions, they create 24.51 times more posts per accounts and 27.38 times more reposts (Fig. 3a). This illustrates their power in influencing the discussions.

135 of these top influencers are individuals. Most individual influencers are internet celebrities with millions of followers. Their comments, likes, and reposts could easily go up more than one million because of their wide social influence. Individual influencers have gradually converged to a focus on economic frame (Fig. 3a, b). Surprisingly, except for a temporary focus on the moral frame in October 2021, moral storytelling on climate change of these individual influencers plays a marginal role.

The other 165 top influencers are institutional actors. Among them, international organizations and non-government organizations are extraordinarily influential (Fig. 3c). One of their key strategies is to have online celebrities serve as their ambassadors. For example, World Wildlife Fund (WWF) worked with Zhu Yilong, a young online celebrity, as its global ambassador for prohibiting illegal wildlife trade, and the United Nations Environment Programme (UNEP) had Wang Junkai, a popular young actor, as its goodwill ambassador. Sometimes these institutions invite celebrities to call for people to participate in their climate activities. Surprisingly, two state-owned enterprises (SOEs), National State Grid (a monopoly in utilities) and Jinneng (a large coal producer), are prominent among firm influencers to positively respond to the national carbon neutrality target. Other firm influencers are those providing products or services (such as



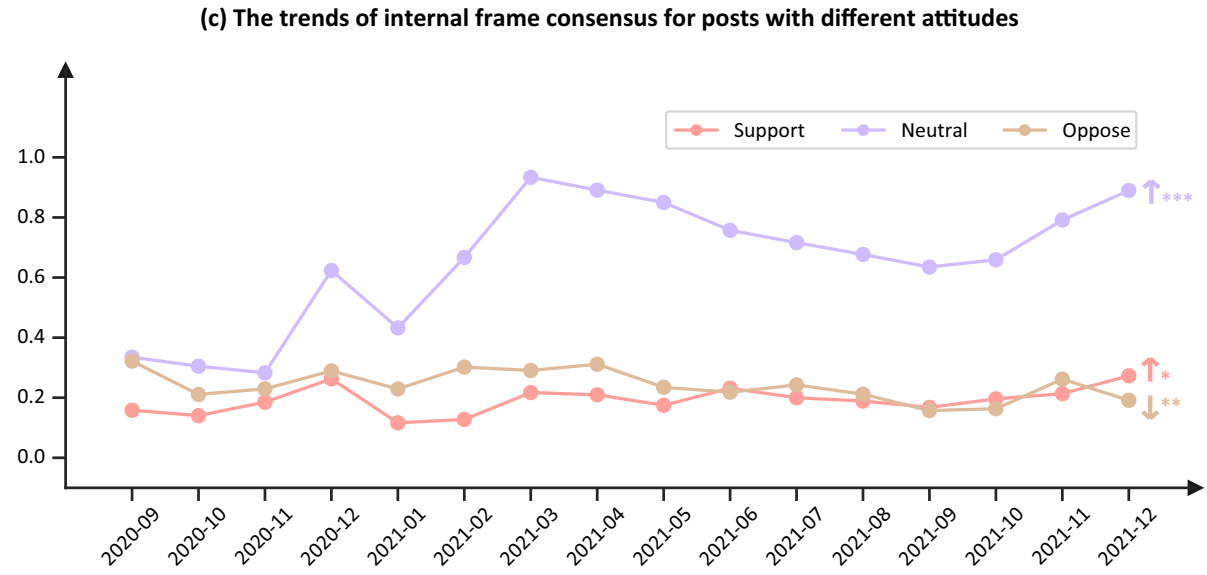


Fig. 2 Climate frames used by supporters, opposers, and the neutral in China. a Distribution of frames used by posts with (i) supportive, (ii) neutral, and (iii) opposing attitude. **b** Monthly frame distributions with (i) supportive, (ii) neutral, and (iii) opposing attitude. **c** The trends of internal frame consensus for posts with different attitude. The * is the significance of the upward or downward changing trends where * represents $p < 0.1$, ** represents $p < 0.05$, and *** represents $p < 0.01$, respectively.

food, electrical appliances and clothing) to end-customers. Famous state-affiliated medias, such as CCTV and People's Daily are part of the influencer list. New media, such as NewsHead and Guancha, are also emerging as main influencers. However, the media influencers are less influential compared with other institutions.

Among institutional influencers, government institutions are working hardest to create climate posts online but made fewer impacts, demonstrated as the average lower reposts. There are two potential explanations behind this observation. First, their carbon neutrality contents are rendered less attractive by the use of more neutral words and by being repetitive. Second, unlike

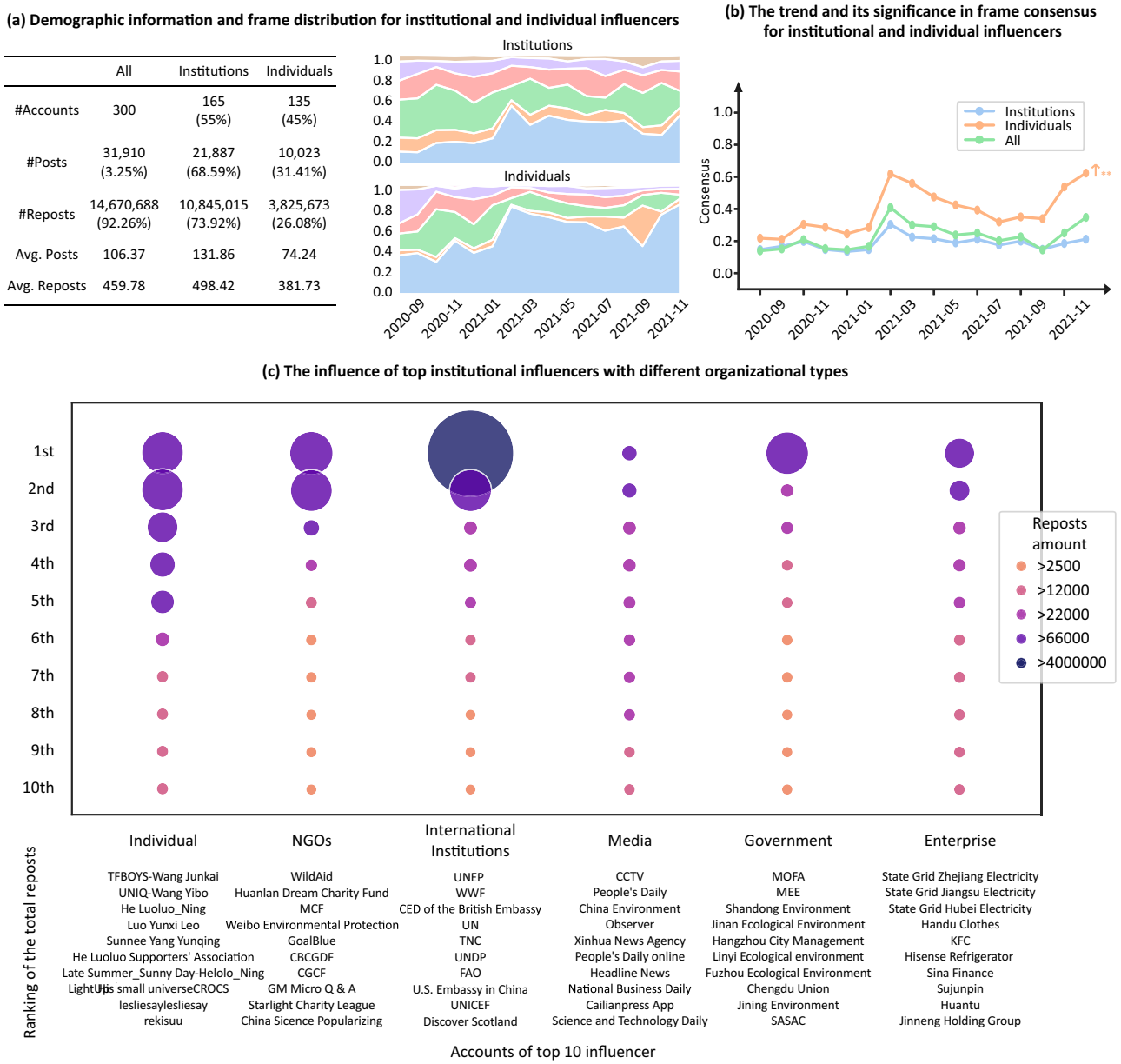


Fig. 3 Influencers and their strategies on carbon neutrality. a Demographic information and frame distribution for institutional and individual influencers; **b** The trend and its significance in frame consensus for institutional and individual influencers; **c** The influence of top institutional influencers with different organizational types.

international organizations or NGOs, they seldom collaborate with celebrities or opinion leaders.

Influences of different government agencies and their internal consensus. The Chinese government has high internal consensus for supporting carbon neutrality but with a low frame consensus (Fig. 4a, b). Ministries use frames aligning with their jurisdiction and administrative responsibilities. The Ministry of Foreign Affairs (MFA) only uses the global frame. National Development Reform Commission (NDRC), as a former ministry in charge of climate change, mainly uses political and economic frames (Fig. 4c). Ministry of Environment and Ecology (MEE), in charge of climate change, has used political and global frames relatively more. The Ministry of Industry and Information Technology (MIIT) favors the economic frame. MOST is the one that uses scientific frame the most. As representatives of SOEs, State-owned Assets Supervision and Administration Commission (SASAC) uses energy security more publicly.

An interesting observation is that the MFA, rather than MEE or NDRC, is the most influential government influencer online indicated by its high volume of reposts. Its influences overshadowed that of MEE and NDRC who were directly in charge of climate change in China. Although MEE and its provincial/ local branches on the east coast of China are also among the list of major influencers, their total influences (measured as total reposts) is still limited compared with MFA too.

Impacts of government policy and political events on the public. The Chinese government has taken increasing measures to convert its carbon neutrality goal into actions. The research further examines the relationships between the government's three types of efforts, namely climate policies, domestic political events, and international political events, and the

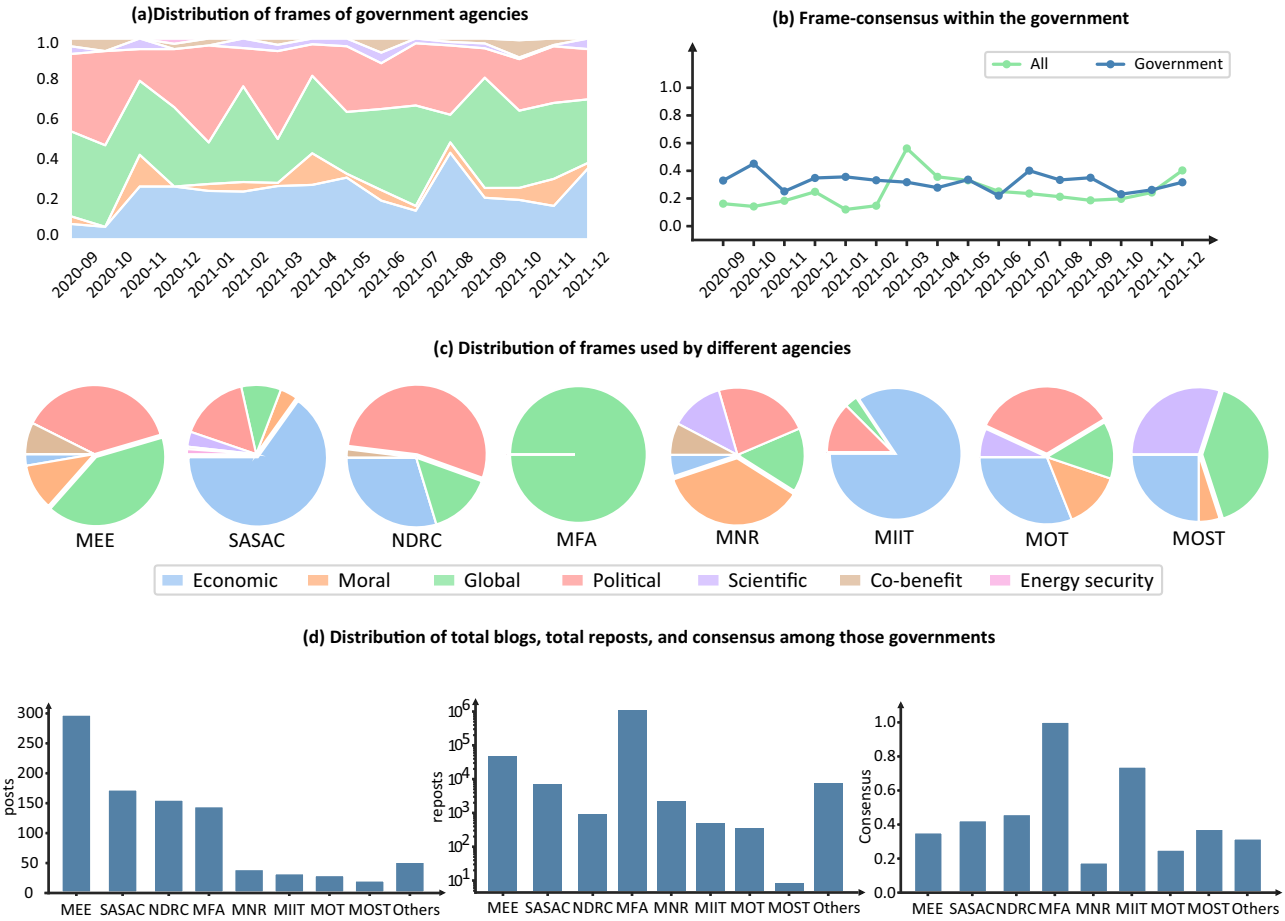


Fig. 4 Influences of different government agencies and their internal consensus. a Distribution of frames of government agencies; **b** frame-consensus within the government; **c** frames used by different agencies and those governments' internal frame consensus; **d** distribution of total blogs, total reposts, and frame-consensus among those governments. Notes: MEE is the acronym of Ministry of Environment and Ecology, SASAC of State-owned Assets Supervision and Administration Commission of the State Council, NDRC of National Development and Reform Commission, MFA of Ministry of Foreign Affairs, MNR of Ministry of Natural Resource, MIIT of Ministry of Industry and Information Technology, MOT of Ministry of Transportation, MOST of Ministry of Science and Technology. Others include Ministry of Finance, Ministry of Culture and Tourism, People's Bank of China, and Office of the State Council.

changes of public opinion and internal consensus (Method and Supplementary Note 3).

The results indicate that the public responds differently toward key policies and domestic politics. Major climate policies that substantially materialize the government' intents on carbon neutrality have strong and relatively long influences. The examples are announcement of stopping the funding of coal power plants overseas and "1 + N" climate policy framework. The two policies are followed by more than three-day increases in climate posts (Event A and B in Fig. 5). Climate policies that are symbolic, such as including carbon neutrality in China's Five-Year Plan, hardly attract the public (Supplementary Note 4). Surprisingly, the public does not respond to purely political wills in carbon neutrality vowed in domestic events without delivering any concrete measures. For example, the Ninth Meeting of the Central Finance and Economics Committee on March 15, 2021, in which President XI theorized carbon neutrality as a broad and profound economic and social systemic reform and called for more actions, did not trigger any boost in posts (Event C and D in Fig. 5). International political events only created an immediate one or days' hike in post creation and reposts (Event E and F in Fig. 5).

Climate polices and political events also differ regarding their influences on supporters, opposers, and internal consensus of attitude communities. Major credible climate policies simultaneously energize supporters and opposers (Event A and B in Fig. 5). Attitude-based internal consensus is then conditional on the redistribution of those policies among supporters and opposers. International political events have similar double-sided impacts in their short-term period of influences (Event E and F in Fig. 5). A show of political will from high-profile leaders through domestic political events can have medium and short-term depressing impacts on opposing forces. Still, the rhetoric and clarities of political messages through these events matter. A typical example is the Central Economic Work Conference in December of 2021 when the government emphasized carbon neutrality and meanwhile highlighted the importance of coal. This inconsistent political message created more confusion, energized opposers, and therefore decrease consensus (Event C in Fig. 5).

Discussions

China's carbon neutrality goal is primarily a top-down target setting process due to a unitary hierarchy of the Chinese political system[26]. Public support, however, matters when it comes to enacting costly climate policies because strong evidence exists that public discontent over environmental problems has motivated the Chinese government to adopt or refine policies[27,28]. This research

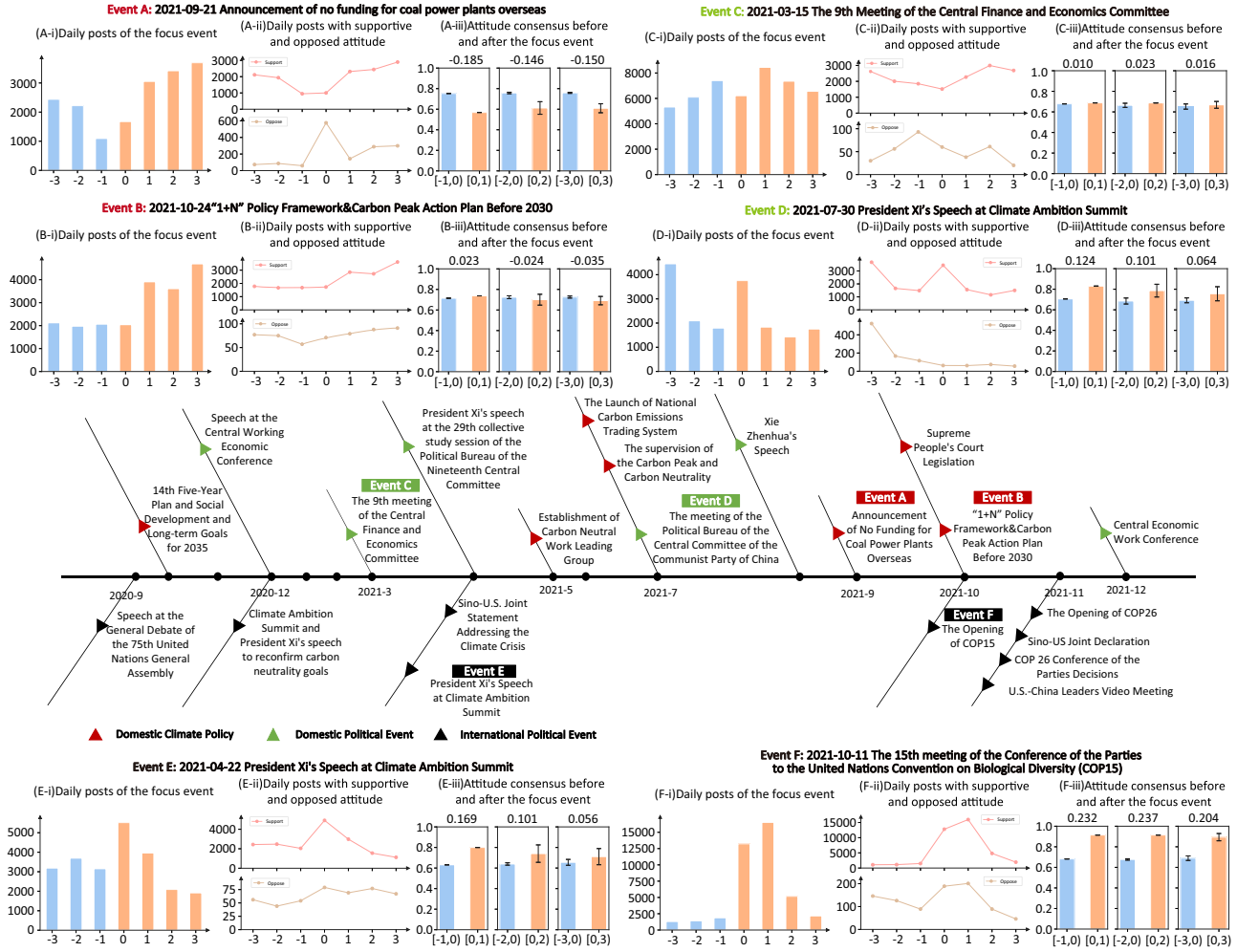


Fig. 5 Changes of posts, supportive posts, opposing posts, and attitude consensus around six key government activities. Zero on X-axis in figures refers to the day that focus event occurred. Negative values on X-axis refer to days before the events whereas positive values on X-axis are days after the focus events. Event A and B are climate policies, followed by more than three-day increases in climate posts. Event C and D are domestic political events and do not trigger any boost in posts. Event E and F are international political events, only create an immediate one or days' hike in post creation and reposts.

identifies a relatively high level of support surrounding China's carbon neutrality goals among participants engaging with carbon neutrality discussions on Weibo. A quarter of posts hold a neutral position and a mere three percent of online contents explicitly raises objections. It's important to acknowledge that the community involved in carbon neutrality discussions on Weibo represents only a small fraction of all microblog users. Furthermore, the Weibo user base predominantly consists of the younger demographic, individuals with higher education, citizens coming from Beijing and other developed provinces etc. rather than the over Chinese population. Our sample also indicates with a relatively higher participation of males in discussions about carbon neutrality. Therefore, the discourse analysis may reflect those people's perspectives more (see Supplementary Note 2 for more detail analysis on the user profiles), rather than the viewpoints of the entire population in China. Also, as Chinese are culturally discouraged to express objections in public, objections might be undermined in practice.

Additionally, opposing forces against carbon neutrality actions are mainly individuals, lacking institutional actors. This echoes to existing studies where the opposing and skeptical posts are marginal and posts containing climate change skepticism are posted by individuals rather than institutions[19]. Specially, opposers focus on global and moral concerns to argue against carbon neutrality in China. They are becoming increasingly divided regarding the used frames. This reflects the increasing struggle over economic disparities, political beliefs, social recognition, and identity among this group. The divided contrarian community, together with their unorganized features, partially explains the marginal objection content online against carbon neutrality. However, an increasing diversified frame portfolio might potentially attract more members. People holding neutral views on carbon neutrality are more attractive to an economic narrative, which provides policy implications for governments to use economic frame to mobilize the neutrals in the future. The challenge, however, is that economic frame is vulnerable to external changes. Economic passion could quickly fade when economic costs affiliated with carbon neutrality actions emerge.

Increasing policy credibility has double-sided effects because it irritates opposers and therefore potentially sacrifices internal consensus. This indicates that when new climate policies come out, policymakers should be prepared for backlash and take compensatory measures to widen the acceptance of climate policies. Politics that are influential for officials and politicians within China's administrative system are less effective in mobilizing the public. Pure political will indications from politicians have little or fleeting impact.

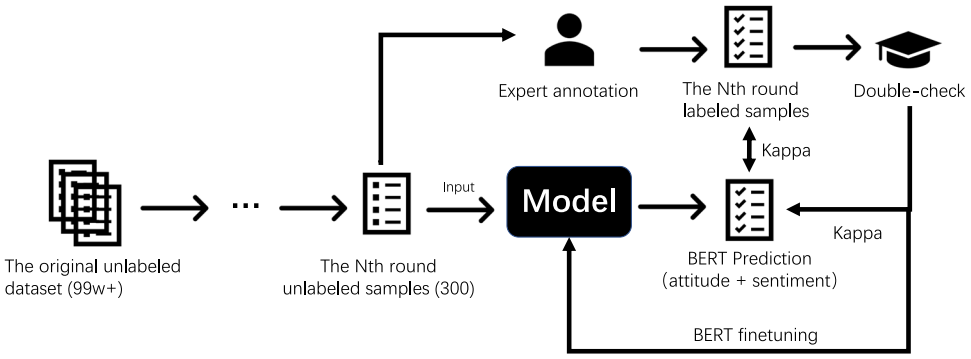


Fig. 6 The process to train the model to label frames and attitudes for the 0.98 million collected microblog posts. This process is a three-phase iterative workflow including (1) the sampling phase to randomly select posts from full volume dataset for training and predicting; (2) the coding phase to engage a human expert to code the selected posts and double check with another expert if any uncertain labels identified; (3) the fine-tuning phase to fine-tune the previous mode and evaluate its performance in terms of loss and accuracy.

There are several limitations to this research. First, we only collected data from the Weibo platform which could bring inherent sample selection bias and might ignore certain group of populations that prefer to discuss carbon neutrality in other social media platforms[18]. Future research could expand the data sources to avoid the potential sample selection bias and do some comparative analysis across different platforms. Second, due to lack of data, this study has not explored micro explanations behind different actors. Third, the research mainly focuses on the government's influences on public views and ignores other factors, such as extreme weather and technological progress that might influence or simultaneously influence the public. Fourth, it would be interesting to investigate how public views on carbon neutrality would reshape China's climate policymaking process.

Methods

A three-step active learning approach for coding. This research uses social media as distributed sensors, a popular research method in previous research[29–31], to capture public perceptions of carbon neutrality in China. We use 0.98 million carbon-neutrality-related posts collected from Weibo, one of the largest and most influential social platform in China with more than 500 million monthly active users in 2020[17,32], to dive deep into the evolving views and internal consensus among public in China who engaging into online carbon neutrality discussions. In China, several social media platforms have gained popularity, including WeChat, Weibo, Douyin, and Kuaishou. Among these options, we have chosen Weibo due to its superior attributes in terms of openness, longevity, and user engagement[33], making it an optimal platform for discussing topics such as carbon neutrality. Weibo has been empirically shown to offer a robust public sphere that encourages the sharing of information, facilitates ongoing debates, and creates an environment conducive to discussions on climate-related matters. This attribute has been a key factor in its selection for prior climate perception research studies[19,20,24]. In contrast, WeChat primarily serves as a platform for two-way communication between users, with a focus on maintaining user privacy. Douyin and Kuaishou predominantly enable users to share information in the form of short videos and are not a good channel to do public discussions timely.

For the collected posts, this study uses a process involving both humans and algorithms to code them into seven frames (scientific, moral, economic, co-benefit, energy security, political, and global) and three attitudes (support, object, and neutral) (as defined in Supplementary Note 2). Two human coders read and code a subsample of the texts to create the "training set." Then an algorithm employs the "training set" to extend the accuracy of manual coding to the whole population of texts. More specifically, the study uses the Chinese-Macbert-Large model[34] as the base model. It is a popularly used pre-trained Chinese RoBERTa model that has been trained on sizable unlabeled Chinese corpora and demonstrates a reasonable efficacy in classifying the microblogs. The study takes the active learning approach to fine-tune this model using the labeled microblogs. As shown in Fig. 6, the procedure can be broken down into a "sampling, coding, fine-tuning" workflow. First, in the "sampling" phase, we randomly select a sample of 300 posts from the full volume dataset (0.98 million), then use the last fine-tuned model to predict the label (its frame and attitude) and the associated possibility of the label. We pick the 150 posts with the highest entropy from this sample, then randomly choose another 150 posts from the remaining 150 texts. Second, in the "coding" phase, a human expert codes the labels for these selected 300 blogs. We introduce a double-check process—after the coding, the coder will discuss with another expert any uncertain labels to determine the final label. This process generates a new training set. Third, in the "fine-tuning" phase, we fine-tune the previous model using this new training set and calculate the loss and accuracy of the model.

We repeat this three-step process until the performance of the model stabilizes. Through this three-step workflow, we train a model with an 84.89% accuracy and 0.804 Cohen's kappa value to identify frames, and a model with an 82.06% accuracy and 0.618 Cohen's kappa value to identify attitudes. Note that a Cohen's kappa value above 0.60 has been considered as substantial and above 0.80 has been considered perfect[35]. Hence, taking both metrics into consideration, the performance of our fine-tuned models can be considered acceptable. Finally, we use these fine-tuned models to predict frames and attitudes for all 0.98 million posts.

Please note that both accuracy and kappa have strengths and limitations. The accuracy metric is designed assuming raters' labels are always correct which may overestimate the true agreement among human-rater and AI-rater. On the other hand, the kappa value was designed to incorporate the possibility of guessing but may lower the estimate of agreement excessively. Hence, we calculate both accuracy and kappa value to interpret the reliability of the finetuned model and the results.

Internal consensus measured by the normalized entropy. We consider two types of internal consensus regarding carbon neutrality discussions, including internal frame consensus and internal attitude consensus within different communities. Internal frame consensus refers to extent of the public consistency in using

different frames when it comes to carbon neutrality for a given attitude community. A high internal frame consensus refers to people converging around similar frames, which indicates a low level of divisions regarding the reasons behind their views on carbon neutrality. Internal attitude consensus refers to extent of the public consistency in holding different attitudes toward carbon neutrality. Similarly, a high internal attitude consensus refers to people converging around similar attitudes toward carbon neutrality for a given community.

Specifically, we adopt the normalized information entropy to measure internal consensus for different communities. The function is $s_{l=\{f,a\}} = 1 + \frac{1}{\log_2 N_l}\sum_{j=1}^{N_l} p_l^j \log_2 p_l^j$ where s_f represents normalized internal consensus on frames, s_a represents normalized internal consensus on attitudes, p_f^j and p_a^j represent the percentage of monthly posts with a given frame j and for attitude a, respectively. Hence, a higher normalized information entropy indicates a higher internal consensus. Additionally, an increase in normalized information entropy suggests that the community becomes more aligned with each other when discussing climate changes on social media platforms.

Data. We collected microblogs about carbon neutrality from the Weibo platform from September 2020 to December 2021 in China after the Chinese government first proposed its carbon neutrality goal at the 75th United Nations General Assembly on September 20, 2020. Note that we start our data collection since March 2021 so that we can limit the impacts from the setting "only half-year posts visible" provided by Weibo platform. Additionally, given the restriction of numbers of posts provided for a given query setting by the Weibo platform, for those query that pass the limitation, we add additional query parameters such as posted hour, to create a most comprehensive dataset for this study.

We identified a set of keywords for carbon neutrality through a three-step process. First, we compiled keywords based on an extensive literature review[20,21,36]. (as shown in Table 3 in Supplementary Note. In this step, we excluded terms like "green" and "energy" due to their potential to introduce ambiguity to the concept of carbon neutrality. Second, we employed these initial keywords to search for related microblogs on Weibo. Analyzing these initial microblog samples led us to identify additional keywords that closely pertained to various aspects of carbon neutrality, such as "energy transition" "climate weapon" "climate finance" and so on. Finally, we refined the list of keywords through group discussions involving three experts in the field of carbon neutrality. As a result, we arrived at the following set of keywords, including climate change, climate crisis, climate risks, double carbon, carbon emissions, climate action, global warming, carbon neutrality, carbon peaking, climate hoax, low-carbon development, energy transition, climate weapon, climate finance, and climate summit[25]. We then used open-source tools developed by the social media to collect a total of 996, 675 blogs that mentioned any of these keywords. We further filtered the data to exclude some unrelated blogs, such as skin care in dry weather and hotels in nice climate contexts, and finally obtained a sample of 981,348 active posts (from 235,467 accounts) in China.

Finally, it is worth to note that we adhere to Weibo's authentication mechanism for defining individuals and institutions. On the Weibo platform, users submit authentic details such as their real names if they are institutions, business licenses and other essential materials. Weibo verifies the provided information to ensure accuracy before granting institutional certification. It's worth noting that certain individual accounts exhibit characteristics of institutions, particularly those belong to celebrities and movie actor, as they might be managed by a team or an office under the celebrity's or actor's name. However, categorizing them solely as institutions is debatable, since these accounts are often personal, and some are managed directly by the celebrities themselves. Technically, it's challenging to establish a distinct division among these individual accounts. An alternative approach we employed is to categorize major influencers and ordinary users, with the aim of spotlighting specific groups of celebrities and actors who exert significant influence, if indeed their impact is substantial.

Data availability

Due to the privacy concerns of Weibo users in the raw data, we only provided the processed data at: https://doi.org/10.6084/m9.figshare.24440692.

Code availability

Code will be made available on request.

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F.Z.: Conceptualization, Methodology, Formal analysis, Analyzing, Writing, Writing—original draft, Supervision, and Fund raising, Funding acquisition. M.X.: Data collection, Formal analysis, Analyzing. Y.Y.: Data collection, Tool Development, Formal analysis, Analyzing. K.H.: Conceptualization, Methodology, Data collection and, Formal analysis, Analyzing, Writing, Writing–original draft, Supervision, and Fund raising, Funding acquisition.

Competing interests

The authors declare no competing interests.

Additional information

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