DIGITALLY NETWORKED PUBLIC PARTICIPATION AND CLIMATE CHANGE DISCOURSE: A STUDY OF CLIMATE COMMUNICATION IN CHINA

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Abstract

This dissertation analyses the digitally mediated, expressive, and networked engagement of Chinese publics with climate change discourse and politics. It examines the multifaceted role of new media in fostering dialogic climate communication, public engagement with climate discourse, and democratically inclusive digital public participation within China's unique socio-political landscape. Presented in a manuscript format, the dissertation consists of three research papers, each focusing on different aspects of digitally networked public participation on China's premier microblogging platform, Weibo. These aspects include social interaction relationships among actors, discursive associations among concepts, and the dynamic interplay between these social and ideational relations over time. The research draws on multiple theoretical perspectives from communication studies, political science, environmental sociology, and network science. A network-oriented approach and computational data analysis techniques are employed to investigate the relational structure of social and discursive interactions in climate change communication. The findings extend our understanding of social media's role in public communication and the nuances of environmental discourse and climate politics in China—an important yet understudied country case. The insights derived from this dissertation can help climate policymakers, communication practitioners, and stakeholders develop more informed climate communication strategies, fostering a more informed, involved, and proactive citizenry critical to achieving a sustainable and resilient future.

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1 Chapter 1 Introduction

This dissertation analyses the digitally mediated, expressive, and networked engagement of Chinese publics with climate change discourse and politics. It examines the multifaceted role of new media in fostering dialogic climate communication, public engagement with environmental issues, and democratically inclusive climate actions within China's unique socio-political landscape. Presented in a manuscript format, the dissertation consists of three research papers, each focusing on different aspects of digitally networked public participation on China's premier microblogging platform, Weibo. These aspects include social interaction relationships among actors, discursive associations among concepts, and the dynamic interplay between these social and ideational relations over time. The research draws on multiple theoretical perspectives from communication studies, political science, environmental sociology, and network science. A network-oriented approach and computational data analysis techniques are employed to investigate the relational structure of social and discursive interactions in climate change communication. The findings extend our understanding of social media's role in public communication and the nuances of environmental discourse and climate politics in China—an important yet understudied country case. The insights derived from this dissertation can help climate policymakers, communication practitioners, and stakeholders develop more informed climate communication strategies, fostering a more informed, involved, and proactive citizenry critical to achieving a sustainable and resilient future.

Climate change, with its far-reaching impacts on our planet's natural systems and human societies, stands as one of the most urgent challenges of our time (IPCC, 2018). Risks of this global crisis extend well beyond our natural and ecological systems, intricately interacting with and profoundly influencing the social, political, and economic realms (Beck, 1992; Giddens,

2011; Stern, 2007). However, our current responses to climate imperatives are alarmingly inadequate. At the time of writing, countries' existing national pledges are on track to a 2.6 °C to 2.8 °C global temperature increase by the end of the century (UNEP, 2022). This falls way behind the goal set in the 2015 Paris Agreement, which targets limiting the temperature rise to well below 2 °C, and ideally below 1.5 °C, above pre-industrial levels.

While the urgency for transformative climate action is clear, identifying capable actors, formulating efficient policies, and implementing them effectively are by no means straightforward tasks. Taking energy transition as the example, although there is broad consensus on the long-term sustainability benefits of renewable energy, moving away from traditional energy sources comes with numerous complications and uncertainties. This is because the energy transition is not merely a straightforward substitution of coal power plants with wind turbines or solar panels. Rather, it requires systematic and multi-dimensional transformations of energy infrastructure and economic structures in order to accommodate the generation, distribution, and management of renewable energies (B. Chen, Xiong, Li, Sun, & Yang, 2019; Markard, 2018). At the individual level, it also demands profound shifts in our energy consumption behaviours, as well as the broader socio-cultural environments that shape these patterns (Steg, Perlaviciute, & Van Der Werff, 2015). On the other hand, the development of renewable energies is not without its own set of challenges and potential adverse effects. For instance, large-scale wind and solar installations could potentially disrupt local ecosystems, and the manufacturing process for solar panels and batteries also produces hazardous waste (Rabaia et al., 2021). Tensions in the renewable energy development become particularly evident when the benefits (e.g., improvements in global environmental wellbeing) are not balanced with the costs (e.g., job losses in local industries), thereby resulting in a gap between gains and losses that rather than

mitigate social inequalities (Jenkins, McCauley, Heffron, Stephan, & Rehner, 2016; Sovacool & Dworkin, 2014). Lastly, although the development of renewable energy is a critical piece in the climate change puzzle, it is not a panacea to solve the problem once and for all. Beyond technologies, we need deep reflections on broader issues such as how we define prosperity, equity, justice, and our relationship with the environment (Jenkins et al., 2016; Sovacool & Dworkin, 2014). To avoid falling into the same trap and perpetuate the very patterns that led us to the climate crisis in the first place, more attention should be directed to the "moral implications of our collective energy decisions" (Sovacool & Dworkin, 2015, p. 435) and the social dimension of sustainability (Agyeman, 2008; Lidskog, Standring, & White, 2022).

Complexities behind the energy transition case underline the necessity for comprehensive, systematic, and holistic approaches in our response to climate change. However, this is not an easy task since climate change is known to be a "wicked problem" (Hulme, 2009). Its causes, impacts, and potential solutions involve a multitude of interlinked factors that span across various societal realms. In recognizing the complexities, many scholars have effectively argued that achieving global sustainability requires more than knowledge and resources embedded in institutional bureaucratic systems (Beck, 1992; Giddens, 2011). Instead, we need concerted efforts that integrate both government bodies and non-institutional forces toward environmental capacity-building (Jänicke, 1997).

1.1. Climate Change: Risks, Citizen Engagement, and Public Communication

There has been a rich body of research highlighting the significance of citizen engagement and participation in relation to climate change issues. Broad engagement and effective participation are critical components in building a more sustainable future, because they not only motivate

changes in individual behaviors and encourage sustainable practices at the community level, but also foster inclusiveness, bolster public support for the making and implementing of environmental policies, and improve the quality of decision-making in environmental governance and management that helps shift our societies towards a more sustainable trajectory (Bulkeley & Mol, 2003; Carvalho, van Wessel, & Maeseele, 2017; Dobson, 2007; Glass & Newig, 2019; Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007; Newig & Fritsch, 2009; Reed, 2008; Whitmarsh, O'Neill, & Lorenzoni, 2011; Whitmarsh, Seyfang, & O'Neill, 2011).

Climate change communication plays a vital role in fostering citizen engagement and public participation in climate change discourse and politics (Kumpu, 2022; Moser, 2010; Moser & Dilling, 2007; Nisbet & Scheufele, 2009; Whitmarsh, O'Neill, et al., 2011; Wibeck, 2014). It is a key process wherein people shape and negotiate their understandings, perceptions, and opinions on climate change and related issues, as well as an important mechanism that reduce people's psychological distance from climate change and foster environmentalist identity (Moser, 2016). Using the previously discussed energy transition as an instance, effective communication first plays a key role in heightening public awareness about the urgent need for transitioning towards more sustainable forms of energy. Supportive public attitudes can be evoked when energy transition is framed to highlight its multifaceted benefits on cleaner air, creation of green jobs, economical costs, and the institutional changes associated with a less centralized energy generation and distribution model, whereas counter frames could influence the effectiveness of communication strategy (Aklin & Urpelainen, 2013).

However, the role of climate change communication in public engagement should not be narrowly taken as only to broadcast "correct" inform or choose the "right" frames to persuade "the public" as if people are empty vessels waiting to be filled with knowledge in order to act

rationally (Whitmarsh, O'Neill, et al., 2011, p. 4). This idea about knowledge gaps are the primary obstacles to climate action is known as the information deficit model (Irwin & Wynne, 1996), which has been a predominant framework in traditional science communication, and much of climate communication still operates in this manner (Suldovsky, 2017). It is rooted in the "ABC" paradigm, which assumes that individuals' attitudes (A) drive the kinds of behaviour (B) they choose (C) to adopt (Shove, 2010). However, the complex and multifaceted knowledge–attitude interface defies such a simplistic conceptual model (e.g., Bak, 2001; Sturgis & Allum, 2004). "Correct" understanding of climate change does not necessarily lead to "appropriate" behaviours to mitigate (e.g., Gardner & Stern, 2002) and people's pro-environmental intentions and their practical actions are often found to be asymmetric in reality (e.g., Blake, 1999; Kollmuss & Agyeman, 2002). In the most basic terms, effective climate change communication strategies should take a varied approach that tailors strategies to effectively connect with diverse audiences in their unique contexts (Boykoff, 2019). Understanding how individuals become engaged (or disengaged) with climate change requires considering their specific contexts, as their perceptions of and capacities to act upon, climate change are significantly molded by their social, political, economic, and cultural environments (Lorenzoni et al., 2007; Semenza et al., 2008; Wolf & Moser, 2011). Beyond this, a more critical limitation of the information deficit model lies in its unidirectional mechanism, wherein knowledge is presumed to flow from "experts" to the "general public". This essentially reflects a "technocratic, reductionist and exclusive" mode of environmental governance (Felt et al., 2007, p. 41), which is likely to perpetuate the prevailing narratives and imaginaries of sustainability defined by experts, governments, and influential business corporations, rather than the voices of less dominant stakeholders. Such a unidirectional approach is insufficient when it comes to tackling intricate environmental problems like climate

change, as it does not little to question the deeply rooted interests and power dynamics that led us to our present socio-ecological problems in the first place.

In recognizing these limitations, scholars have advocated for a shift towards a more dialogical model of public communication and citizen engagement with climate change discourse and politics (Brulle, 2010; Lorenzoni et al., 2007; Pearce, Brown, Nerlich, & Koteyko, 2015; Phillips, 2011; Regan, 2007). A dialogical model offers greater inclusiveness and more opportunities where imaginaries and solutions of collective environmental problems like climate change can be collectively articulated, formulated, and deliberated. Different social groups' diverse knowledge and lived experiences with climate change (Munshi, Kurian, Cretney, Morrison, & Kathlene, 2020) can be better valued in this two-way approach. Cultivating an environment where different stakeholders can exchange perspectives and negotiate understandings helps breaking the conventional barriers between "experts" and the "general public." This can not only bolster the social, political, and cultural resonance of climate actions, but also helps to promote a more democratic and inclusive decision-making process to better address the multifaceted impacts of complex environmental issues like climate change.

The rise of new media has prompted many researchers to explore new communication technologies' potential for fostering citizen engagement in public/political life and rejuvenating the public sphere (e.g., Benkler, 2006; Dahlberg, 2001; Dahlgren, 2005; Papacharissi, 2002). This more interactive and participatory mode of communication differs from the vertically structured and monological "mediated quasi-interaction" carried by traditional media where the production and reception of symbolic forms are separated (Thompson, 1995). Its technological architecture allows for, at least theoretically, structurally decentralized information creation and diffusion, and thereby more opportunities for dialogical interaction knowledge sharing,

deliberation, and interactions among diverse social groups (e.g., Schudson, 2002; Thompson, 2020).

While these theoretical arguments paint an optimistic picture, empirical research brings to light many complications that contradicts the idealistic visions. The literature has pointed to a series of challenges such as echo chambers, mis- and dis-information, digital divide, and other issues that may significantly affect the participatory and dialogical potential of new media. Furthermore, new media's inclusivity and deliberative quality is vulnerable to government interventions and the commercial interests of platform providers (Schudson, 2002), which substantially compromises the communication power envisioned in Habermas's public sphere theory.

With opportunities and challenges co-existing in the new media environment, promising prospects often go hand in hand with notable hurdles. These dynamics provide a fertile research ground. Diving into this rapidly evolving field, my dissertation seeks to probe the multifaceted role of new media in fostering dialogical climate communication, public engagement with environmental issues, and more democratically inclusive climate actions. Specifically, I take a focused lens on the case of China to study the role of new media in climate communication within China's unique socio-political context.

1.2. The Chinese Case: Dual Roles & Citizen Engagement with Climate Change

China's dual role as both a major contributor to GHGs emissions and a key actor in climate mitigation efforts makes it a compelling case study for exploring citizen engagement in climate change discourse and politics.

On one hand, China is currently the world's largest emitter of greenhouse gases, accounting for 24.23% of the global total in 2020 (Climate Watch, 2023). The rapid expansion of its economy has led to substantial carbon footprints, primarily due to its manufacturing-centric, export- and investment-driven economic structure that heavily depends on fossil fuels, particularly coal. Additionally, several analysts express concerns regarding the potential environmental implications of the Belt and Road Initiative — China's ambitious project for overseas infrastructure investment — which could further extend its environmental footprint globally (e.g., Ascensão et al., 2018). At the same time, the country is also exposed to multiple climate change risks. Climate change-induced ecological hazards such as sea-level rise, floods, droughts, and severe heat waves have already begun to manifest in China, threatening the livelihoods of millions, disrupting its agricultural sector, impacting coastal cities, and putting pressure on its public health and infrastructure systems (CMA, 2022; MST, 2022). China's carbon-intensive economic and energy structures are particularly vulnerable to potential disruptions in energy supply, job losses in traditional industrial sectors, and societal challenges as the world moves towards decarbonization goals. Therefore, besides ecological impacts, risks also span across the economic and social domains, constraining the country's long-term growth and prosperity (World Bank Group & Asian Development Bank, 2021).

On the other hand, China is emerging as a leader in various aspects of climate change mitigation. In 2020 at the 75th United Nations General Assembly general debate, Chinese President Xi Jinping pledged to reach peak CO2 emissions before 2030 and to achieve carbon neutrality by 2060. This timeline, also known as the "Dual Carbon Targets" (*双碳目标*), has become a new milestone in China's climate policy agenda, signaling a significant stride to elevate climate change mitigation and environmental sustainability as a national development

priority for the coming decades. The Dual Carbon Targets has spurred the Chinese government to implement a series of national and subnational policies, which has begun to yield significant outcomes. A prime example is the rapid development of renewable energies and green technologies. According to the National Development and Reform Commission, China's installed electricity generation capacity from non-fossil fuel sources has historically surpassed that of fossil fuels, reaching a landmark 50.9% in June 2023 (Xinhua News Agency, 2023). In the year 2022, China's renewable energy generation equated to a reduction of approximately 2.26 billion tons of domestic CO2 emissions, while exported wind and solar power products resulted in a CO2 emission reduction of about 573 million tons in other countries. Combined, these efforts account for 41% of the global emissions reduction attributed to renewable energy development (NEA, 2023).

While China's steps towards low-carbon transitions are promising, the tangible implications of the country's climate policies for building a more sustainable and resilient future still seem unclear. Some substantial challenges may hinder the effectiveness of policy implementation and their societal impacts. Among these hurdles, one of the most prominent is the deficit in public participation and engagement in environmental governance and decision-making processes.

China's environmental governance model often exemplifies a "top–down" approach, in which environmental policies and initiatives are primarily formulated by the central government and subsequently assigned down through the bureaucratic ladder of environmental protection bureaus (EPBs). For instance, the national emission reduction target is divided up and assigned to provincial jurisdictions and state-owned corporations through the Target and Responsibility

system. In this system, local implementation of carbon targets is predominantly driven by bureaucratic factors and motivated political incentives (Eaton & Kostka, 2014; Kostka, 2016).

This "top–down" characteristic has been associated with theoretical concepts such as "authoritarian environmentalism" (Beeson, 2010, 2018; Gilley, 2012), "developmental environmentalism" (S.-Y. Kim & Thurbon, 2015), "new developmentalism" (Dent, 2018). These concepts underscore the importance of strong state capacity and the prominent role of the state, top executive agencies, technocrats, and other policy elites in steering policy processes towards green growth goals. On one hand, centralized decision-making has the advantage of making it relatively straightforward to establish a uniform national stance towards mitigation policies (see also Dubash, 2021). Strong state capacity exercised through a "command-and-control" manner prompts swift and rapid policy enforcement and immediate actions, which is particularly imperative given the urgency of climate change. As showcased by rapid expansion of China's renewable energy industry and other ambitious climate initiatives, this state-led approach, when applied appropriately, can indeed yield substantial outcomes in climate policy (see also Engels, 2018; Jia & Chen, 2019).

However, this top–down model presents significant limitations when it comes to public participation. As posited by Gilley's discussion of authoritarian environmentalism, the top–down environmental governance model requires the concentration of authority to a small group of capable and pro-environmental elites (Gilley, 2012, p. 288). However, environmental commitments at the top governance level may be a slippery ground for building long-term sustainability due the volatile nature of cadre politics, where organizing, directing, and implementing environmental policies are mostly entrusted with a small group of select political elites. More importantly, such a concentration obscures space for the publics and civil society

actors to participate in policy processes. Climate policies may face significant societal pushback when the civil society's meaningful inputs are oft-neglected. This is particularly evident when it comes to addressing complex socio-ecological issues like climate change in the Chinese context, where transitioning towards a low-carbon society demands extensive societal preconditions and inherently impacts society at large. If the diverse effects on various societal sectors are not thoughtfully considered, climate policies may run the risk of inadvertently creating new problems while aiming to solve existing ones. For example, the Chinese government launched the "coal-to-LNG" policy in 2017, which intended to combat air pollution and reduce emissions in the Beijing–Tianjin–Henan region through reducing coal consumption. However, the policy faced serious implementation challenges. Because of soaring gas prices and incomplete heating system installations, many rural residents and low-income households were left suffering through frigid winters without proper heating ("Poor Bear Brunt of Beijing Coal Cleanup with No Heating at -6C," 2017). Incidents like this underscores the necessity of balancing environmental policy enforcement with other facets of sustainable development — especially the need to ensure social justice as an integral and critical component of sustainability (Agyeman, 2008).

Achieving balance between different aspects of sustainability calls for public dialogues that allow diverse voices, viewpoints, and even competing interests to be openly expressed and deliberated during policy processes. However, the institutional avenues for Chinese citizens to participate in such public dialogues are still underdeveloped (Kostka & Mol, 2013), even though the legislative foundation for citizen involvement in environmental planning processes has long been established since the promulgation of the Environmental Impact Assessment (EIA) Law in 2002. The efficacy of EIA-based participation channels — such as public hearings, hotlines, and

complaint letters — hampered by a lack of transparency and political constraints in practice (M. Chen, Qian, & Zhang, 2015; W. Li, Liu, & Li, 2012; S.-Y. Tang, Tang, & Lo, 2005).

Outside the formal political realms, alternative avenues for public participation have gradually emerged and evolved. These include NIMBYist activism (T. Johnson, 2010), environmental journalism (J. Li, 2020; Tong, 2015), and increasingly, online public spaces facilitated by digital media technologies, providing new opportunities for citizens to voice their concerns and express their opinions on environmental issues. These channels serve an important role in bridging the void left by formal public participation mechanisms, allowing for Chinese citizens to exercise what Habermas called communicative power (1996), exert public pressure, and advocating for greater transparency and accountability in environmental governance processes.

Understanding these dynamics and investigating whether and how dynamics in this digital public sphere could contribute to dialogical public participation and citizen engagement becomes an increasingly important aspect of research. So far, the literature has pointed out several characteristics that help us understand the uniqueness of the Chinese publics' engagement in environmental governance and movement. First, studies have shown that Chinese environmental groups and activists generally adopt a non-confrontational approach, which is in contrast with their counterpart in Western societies. Their activities tend to focus on raising public awareness, campaigning green lifestyle, promoting sustainable everyday behaviours, and other practices that nudge cultural changes towards a more environmentally sustainable future (Ho, 2001; Ho & Edmonds, 2007; Sima, 2011; Skoric & Zhang, 2019). Even when addressing contentious environmental issues, environmental actors tend to practice self-censorship and deliberately eschew direct political criticism or calls for systemic political reform. Instead, their actions target

business practices or individual officials (Ho, 2001). Interestingly, this depoliticalized and non-disruptive stance is not viewed as a weakness by Chinese ENGOs; instead, it is seen as a sign of savvy strategy that allows them to leverage resources within the constraints of the given political context (J. Y. Zhang & Barr, 2013, p. 72).

Another key characteristic is related to the critical role of digital communication technology in the development of public sphere and civil society in contemporary China (Lei, 2018; Tai, 2006; W. Tang, 2005; G. Yang, 2003, 2009). Research has well-documented the power of the so-called online "public opinion incidents" or "mass incidents", where Chinese netizens' heated online discussions bring social grievance under the spotlight and transform these individual incidents into collective affairs on the public agenda in China (deLisle, Goldstein, & Yang, 2016; R. Huang & Sun, 2014). Netizens' impact becomes intensified with the advent of social media platforms, as they began to shape public opinion incidents by actively engaging with and spreading posts. This has given rise to a cultural practice known as the "surrounding gaze" (*围观*), where users' attention and discussion on public affairs scale up to become a collective form of scrutiny and observation that amplifies social accountability, exerts influence on political processes, and challenges official narratives over public/political affairs in China (Nip & Fu, 2016; Sullivan, 2014; Teng & Mosher, 2020; Zuo & Tong, 2015). As such, many researchers argue that the increasing connectivity among citizens and their participation in online surrounding gaze contribute to the growth of public sphere and profoundly alter the fabric of China's civil society in China (W. Chen, 2016; Lei, 2018; Svensson, 2016; Tai, 2007). Specific to the environmental field, Yang (2003) posits that the development trace of environmental movement parallels with the advent and proliferation of the Internet in the 1990s (pp. 405–406). This coevolution of online public space and environmentalism has fostered the emergence of a

"green public sphere", where ENGOs and citizens generate and engage with "greenspeak" (i.e., environmental discourse) as a way to reflect upon and challenge the prevailing material growth-centered narratives in the country (G. Yang & Calhoun, 2007, pp. 212–214). A rich body of research has subsequently emerged to study the role of green public sphere in facilitating environmental actors disseminate environmental information, build networks with stakeholders, increase public visibility (e.g., Deluca, Brunner, & Sun, 2016; Eberhardt, 2015; Jingfang Liu, 2011; Rauchfleisch & Schäfer, 2015; Shao & Wang, 2017; Sima, 2011; G. Yang & Calhoun, 2007; N. Zhang & Skoric, 2020), as well as its role in both online and offline (non-disruptive) protests (e.g., W. Li et al., 2012; Jun Liu, 2017; Shen & Wang, 2023; Skoric & Zhang, 2019; Steinhardt & Wu, 2016).

While the research on the green public sphere continues to develop, much of it is based on a somewhat narrow conception of "the public" and focuses on environmental "elite" such as activists, journalists, and ENGOs. What remains underrepresented is the peripheral part of the green public sphere and how the peripheral interact with the core. Some researchers argue that China's green public sphere is not citizen-centric (Y. Sun, Graham, & Broersma, 2017, p. 248), but is a "gated" discursive space (Sima, 2011, p. 492), or "a public sphere without the public" (Eberhardt, 2015, p. 33). However, as I will discuss in my dissertation, outside this small circle of environmental actors stands much larger groups of publics who constitute the "issue publics" (Dahlgren, 2009), "networked publics" (boyd, 2010), or "affective publics" (Papacharissi, 2015) around climate change issues.

Since Verba and Nie's landmark work on public participation, we have seen its meaning has undergone significant change (for reviews, see Ekman & Amnå, 2012; Van Deth, 2014). Initially focused on election-centered activities aimed at "influencing the selection of

governmental personnel and/or the actions they take" (Verba & Nie, 1987, p. 2), the concept of public participation has been expanded to encompass a range of individualized, expressive, lifestyle-focused forms of citizen engagement that encapsulate a "DIY" approach (Bennett, 2008; Bennett & Segerberg, 2012; Micheletti, 2003). The growing disenchantment with conventional political structures is anchored in a more fundamental transformation of our society towards what Beck refers to as "sub-politics" (1997). As a consequence of reflexive modernization, political decisions, actions, and transformations are increasingly being taken outside of traditional political institutions (Beck, 1997). Sub-political activities often hinge on mediated communicative events to mobilize public pressure from a broad spectrum of publics that exist beyond the confines of institutionalized politics (Beck, 1997, pp. 52–54). Communication technologies play an important role in this context as they facilitate diversified actors with an array of participation repertoires such as political consumerism, NGO-initiative media events, online campaigns and so on. Instances of these participatory actions might appear to be transient, tangential, or issue specific mundane behaviours, especially when conducted in online settings, yet their implications are far from trivial in the context of public participation and civic engagement. While these communicative actions may lack the formal structure and rule-guided process of conventional deliberation, the continuous exchange of ideas, perspectives, and experiences play a crucial role in forming the bedrock of "everyday politics" (Benkler, 2006; Dahlgren, 2005; Neblo, 2015; Shirky, 2011). As Dahlgren (2005) argues, civic culture is "anchored in the mind-sets and symbolic milieu of everyday life" (p. 158). Everyday communicative actions make public/political agenda more accessible and relatable to individuals, thereby contributing to a more informed, engaged, and active citizenry over time.

In line with such considerations, I view the digital green public sphere as a space where climate change discourses, communicative actions, and citizen engagement dynamically interact with each other within the context of individuals' lived experiences, whether online or offline. Online climate communication, thereby, is not only an arena where people collectively construct environmental discourses based on their own lived experiences, but also a venue where their environmental engagement and actions (or lack thereof) is continuously shaped by these discourses.

Building on this understanding, my dissertation focuses on studying Chinese publics' digitally mediated, expressive, and networked form of engagement with climate change discourse and politics on the country's premier microblogging platform Weibo. Weibo, often referred to as the Chinese equivalent of Twitter, is a leading social media platform in China that combines features of microblogging and social networking. Launched in 2009 by Sina Corporation, Weibo allows users to post short messages, share multimedia content, follow other users, and engage in discussions on a wide range of topics. With approximately 587 million monthly active users (Weibo Data Centre, 2024), Weibo serves as a hub for public discourse, celebrity culture, and marketing. Nearly 80% of Weibo's user base consists of individuals born in the 1990s and 2000s (Weibo Data Centre, 2024), a highly active and digitally savvy cohort. Additionally, women make up 55% of Weibo's users (Weibo Data Centre, 2024), signaling the platform's popularity among female internet users. Furthermore, Weibo has a significant presence in China's first-, second-, and third-tier cities, with over 70% of its user base coming from these urban areas (Weibo Data Centre, 2024), making it an essential social media platform for young and tech-savvy urban users. Weibo's user dynamics are characterized by a diverse range of participants, including celebrities, journalists, influencers (often called Key Opinion

Leaders, or KOLs), academics, and ordinary citizens. With its vast user base and high engagement levels, Weibo is a significant space for public discourse, information dissemination, and social interaction in China.

The history of Sina Corporation is integral to understanding Weibo's development and its place in the broader digital media landscape. Established in 1998, Sina Corporation initially focused on web portals and online news, becoming one of China's earliest internet companies to achieve international recognition. With its launch of Weibo, Sina capitalized on the global rise of social media and adapted it to meet domestic market demands, including compliance with stringent government regulations. The political economy of Sina Corporation reflects broader trends in Chinese internet governance, as the platform operates under state oversight while pursuing profitability through advertising, e-commerce integration, and paid content features.

Weibo's technological architecture sets it apart from other popular Chinese digital platforms. Unlike WeChat's closed-group communication model or Douyin's algorithm-driven video content feeds, Weibo offers an open content-sharing framework that emphasizes visibility, interactivity, and trending discussions. Users can follow accounts without mutual consent, participate in hashtag campaigns, and engage in threaded public discussions. This architecture fosters a unique dynamic where content amplification is often driven by virality and user-generated momentum, rather than purely algorithmic curation. These structural features position Weibo as an important space for public debate within China's digital media environment.

Investigation in this dissertation is set out to analyse the communicative mechanisms that underlie the formation and development of public understandings of climate change and citizen engagement with climate change discourse and politics within China's unique socio-political landscape. Specifically, this dissertation asks three sets of research questions: 1) How do

interaction patterns and information flows within the climate communication network reflect the dynamics between state actors and the public and what are their implications for understanding the potential of Weibo to foster meaningful public engagement and deliberation on climate change? 2) How have major climate change topics evolved on Weibo over the past decade and what can the relational structure of topic associations reveal about the public discourse of climate change? 3) Do communication relationship influence actors to become more participatory or do participatory actors select to be connected with similar others in climate communication? How do the interactions between social selection and influence processes help us better understand the dynamic interplay between public communication and civic participation in online space? My research draws on multiple theoretical perspectives that traverse varied yet interconnected research fields and analytical strands, including communication studies, political science, environmental sociology, and network science. By focusing on the Chinese case, my work aims to contribute to the scholarship that probes the multifaceted online citizen engagement outside the Western democratic socio-political framework.

1.3. Methodology: Social Network Analysis

As a general methodological overview, my research takes on a network-oriented approach and utilizes computational data analysis techniques to investigate the network relational structure of social and discursive interactions in climate change communication.

Borrowing Diani's analogy, the notion of network can be stretched "from metaphor to substance" (2003, p. 1). On the theoretical side, Castells's seminal work on network society offers a compelling discussion on the increasing importance of a network logic as the new social morphology and the organizing principle for our macro systems of the economy, society, and

culture. Castells contends that the backbone of contemporary society is being reshaped in the mold of networked structures, which fundamentally alter the mechanics and consequences of production, experience, power, and culture. In the specific context of civic communication and public participation, concepts such as networked public sphere (Benkler, 2006), networked publics (boyd, 2010), networked individualism (Rainie & Wellman, 2012), and digitally networked participation (Theocharis, 2015) all highlight the pivotal role of network structure in organizing social relations, mediating public discourse, and fostering new forms of community in our civic life. The networked morphology has profound implications for citizen engagement and public participation. A more distributed network structure is often hailed as holding greater democratizing potential. Compared with the traditionally centralized, formal group-based, and geographically-bound models, networked structures offer more opportunities to form decentralized, inclusive, and participatory arena for civic communication and public participation (Rainie & Wellman, 2012). However, the rising centrality of networks in our civic life also introduces new challenges. Issues such as rampant spread of misinformation that distorts "public" opinion, the persistent digital divide that exacerbates existing marginalization, and polarized echo chambers that accelerated by platform algorithms, all point to the complexities of networks in our digital age. These emerging tensions and dynamics present a fertile ground for research, and it is against this backdrop that my investigation is carried out. By focusing on analysing network connectivity, my work aims to contribute more nuanced understandings of the multifaceted relationship between digital networks and citizen engagement.

Besides being as a general conceptual lens, a network perspective also serves as the principal empirical tool in my research for measuring, mapping, and analysing the structure of

relationships among actors, among concepts, and between actors and concepts in climate change communication.

As Crossley argues, sociological research has long gravitated towards the "individualist" or the "holistic" poles, either reducing the social world to an aggregation of discrete individuals with social behaviors regressed to individual attributes and traits, or treating society as a macro entity, subject to its own laws and logics and largely independent of individual actors (2011, p. 7). Network analysis provides a valuable relational methodological tool to address this micro–macro dualism. The network analysis framework emphasizes the idea that actors' social actions are not insulated but significantly shaped by the network structure within which they operate (Wasserman & Faust, 1994). By treating social actors as "agents-in-relation" (Crossley, 2011), network analysis methods redirect the analytical focus onto the relationships among social actors, therefore helps bridging the macro–micro link (Alexander, 1987) and examining the interplay between agency and structure in collectively shaping social actions (Emirbayer & Goodwin, 1994; Emirbayer & Mische, 1998). This emphasis on relational dynamics forms a cornerstone of my research and consistently informs the analyses undertaken throughout my dissertation.

1.4. Manuscript Outlines

In a manuscript format, my dissertation consists of three full research papers. Each manuscript discusses a different, yet interrelated, aspect of digitally networked public participation in climate change discourse and politics in China.

The first manuscript[1] focuses on the ideational aspect of climate change discourse on Weibo and the evolution of major climate change topics during the past decade (2009–2020). I first employ topic modelling — a natural language processing tool for computational text analysis — to analyse the latent thematical structure of user generated social media text data whose volume is too large to be processed manually. Since climate change is a multifaceted issue, identifying topics helps us understand the major themes of concerns, debates, and narratives around climate change in public discourse on Weibo. The second focus of this manuscript is topic association in individuals' online expressions. Linguists and semiotician have long posited that meaning doesn't inherently reside within words but is derived from their relational position within "a system of differences" (Saussure, 2011) or the relations between signs that make up a language (Bertens, 2014). Specific to the environmental context, Lakoff (2010) argues for the importance of the relational aspect of frames by explaining that frames are not just individual concepts, but rather interconnected systems of concepts that shape our understanding of complex environmental issues. Drawing on the idea that meaning is relational, I analyse the relational structure of topic co-occurrence in individuals' online expressions about climate change on Weibo. Examining the relational structure of topic association gives a nuanced picture of how different facets of climate change issues intersect or diverge, and thus illuminating areas of shared understanding as well as points of divergence in public discourse.

My network analysis of topic association reveals that topics cluster into two distinct yet aligned thematic camps, showing an environmentalism and a developmentalism orientation to frame climate change, respectively. Identifying these two thematic axes and their relationship in

[1] The first manuscript was published as a research paper in *Politics and Governance* in 2021, co-authored with my PhD supervisor Dr. Mark C.J. Stoddart. Author contribution to this journal publication is as follows: Y. Yang: conceptualization, data collection and analysis, writing–original draft preparation, visualization. M. Stoddart: conceptualization, resources, writing–review and editing, supervision, funding acquisition.

the public discourse helps us better understand the underlying discursive and cognitive structures that inform Chinese publics' understanding and attitudes towards climate change. Further analysis on topics' temporal prevalence in the corpus uncovers the ebb and flow of various discussion topics over the decade, providing insights into shifting public attention between the environmentalism and developmentalism orientations in public discourse on Weibo. The evolution of topic prevalence in online public discourse is discussed in the context of the development of China's home-cultivated Ecological Civilization discourse in official narratives.

The second manuscript investigates the structure of information flows in climate communication network on Weibo. My focus is to examine interaction patterns in information diffusion and public discussion about climate change between different types of actors within the network context. The Chinese state's dominance in environmental governance, characterized by its top-down approach, presents a unique backdrop against which to examine how climate change discourse evolves and is structured in the public sphere. Therefore, special attention is paid to the interaction between state actors, including government actors and official media organizations, with others in terms of the trajectories of information flow, the shaping of climate narratives, and the interaction patterns within Weibo's digital communication landscape.

Through comparing the network-level structure of the communication network for the IPCC *Fifth Assessment Report* and the one of the IPCC *Special Report on Global Warming of 1.5 °C*, I find a general expansion of public engagement in spreading and discussing of climate change information between the pre- and post-Paris Agreement (2015) periods. This is marked by enhanced individual influence in the communication network and diversified discussion frames for climate change. However, exponential Random Graph Models (ERGMs) reveal three restrictive interaction tendencies that may limit Weibo's potential to facilitate meaningful public

engagement and deliberation in climate communication. These include the decline of mutually balanced dialogical interactions, the lack of bottom-up information flows, and the reinforcement of homophily tendencies amongst environmental elite actors and governmental users. Linking China's top–down environmental governance approach in the political sphere to the realm of public discourse, I find that state actors' dominance seems extend beyond policymaking into public communication and shape the public dialogue on climate change. These findings highlight the coexistence of both opportunities and constraints of Weibo being a venue for public engagement with climate communication and a channel for citizens' online expressive participation in two-way dialogues between state actors and publics. As countries around the world grapple with the urgency of climate action, the insights gained from this study could, in turn, inform how we leverage digital communication networks for more participatory climate communication and public engagement strategies that accommodate varied governance models.

The last manuscript[2] addresses the "selection versus influence" question in the context of digitally mediated public participation. As a key point of discussion among network researchers and an active area of research in social network analysis, the "selection versus influence" question asks whether network autocorrelation is primarily due to individuals choosing to interact with similar others (i.e., selection), or because they are influenced by those who they interact with to become more similar (i.e., influence) (Aral, Muchnik, & Sundararajan, 2009; Crandall, Cosley, Huttenlocher, Kleinberg, & Suri, 2008; K. Lewis, Gonzalez, & Kaufman, 2012). In our context, this distinction can have substantial implications for how we understand

[2] The third manuscript was submitted to *New Media & Society* and it has been revised and resubmitted to the journal in November 2024. This manuscript is co-authored with my PhD supervisor Dr. Mark C.J. Stoddart. Author contribution to this journal publication is as follows: Y. Yang: conceptualization, data collection and analysis, writing–original draft preparation, visualization. M. Stoddart: conceptualization, resources, writing–review and editing, supervision.

online social networks' role in relation to public participation and, consequently, for the strategies we develop to leverage these networks for promoting public participation and civic engagement. Although communication researchers have established a generally positive association between informational and interactional use of social media and people's involvement in public/political life (Boulianne, 2015a; Skoric, Zhu, Goh, & Pang, 2016), the temporal order between social media use and participatory behaviours remain largely undistinguished in previous research as the observed data often contain a mix of effects from both directions. In this manuscript, I draw on the reinforcing spiral model (RSM) as the theoretical framework and longitudinal network analysis as the methodological tool to disentangle the two competing processes and analyse their dynamic interactions in the co-evolution of climate change communication network relations and individuals' engagement with China's climate policy-related online expressive participation on Weibo. Specifically, I use Stochastic Actor-Oriented Models (SAOM) to jointly model the temporal changes between communicative ties and individual participation behaviours in a three-year time period.

Overall, I find a mutual influence between communication network social ties and individual participation behaviours over time, which is generally corroborative with the RSM's proposition on the reciprocal impact between political communication and its attitudinal/behavioural outcomes. Furthermore, results of this manuscript reveal several importance nuances in this dynamic process. First, the mutual influence does not appear to operate at the individual level through a simple "more communication ties lead to more participatory actions or vice versa" mechanism. Instead, it is characterized by a combination of homophilic network selection (i.e., actors with similar participation levels are more likely to become discussion partners over time) and network influence towards behavior homogeneity

(i.e., actors tend to be influenced by their discussion partners to adopt a similar participation level over time). Both processes drive the communication-participation co-evolution on Weibo, but the network selection effect is more pronounced than network influence in our dataset. Furthermore, we found that endogenous network structural factors, including reciprocity, transitivity, preferential attachment, and degree centrality, plays a significant role in shaping people's engagement with climate change communication on Weibo. These findings highlight the importance of the relational dimension in examining the dynamic interplay between communication and participation. The results of this study not only provide insights into public engagement with the climate change discourse in China's social media sphere, but also contribute to the emerging Reinforcing Spirals Model (RSM) theory with empirical evidence from a network perspective.

1.5. Conclusion

These three manuscripts that make up this thesis contribute to three main areas of literature, including 1) a substantive topic contribution to social media and public communication and participation research; 2) a regional study contribution to environmental and climate politics in China; and 3) a methodological contribution to examining social media communication using social network analysis and computational text analysis methods. I will revisit and discuss the contributions of this dissertation in greater detail in the concluding chapter, including discussions on the theoretical, methodological, and practical implications and impacts.

Together, studies in my dissertation research present an in-depth analysis of Chinese publics' digitally networked engagement with climate change discourse and politics on Weibo.

As we navigate through the urgent challenges posed by climate change, the importance of fostering more active, meaningful, and dialogical public engagement becomes paramount. Learnings from this dissertation shed light on online citizen participation in the Chinese climate change discourse and politics, which contribute to the existing body of knowledge that has often been grounded in Western democratic settings. From a practical standpoint, findings on the prevailing frames, narratives, and discourses of the Chinese publics regarding climate issues, as well as the mechanisms that underpin their formations, provide important insights for policymakers, ENGOs, and stakeholders to tailor communication strategies to foster greater support for climate policies and mobilization around climate actions in China, in a culturally resonant and socially inclusive manner. Lastly, the contribution of this dissertation extends beyond the specific Chinese context. As climate change continues to pose unprecedented challenges, and digital technologies increasingly shape our information landscapes, better understandings of the interplay between these two realms offer valuable insights that inform climate change communication strategies and the cultivation of a more informed, involved, and proactive citizenry critical towards a more sustainable and resilient future.

2. Chapter 2 Public Engagement in Climate Communication on China's Weibo: Network Structure and Information Flows

1.1 Abstract

This article provides an empirical study of public engagement with climate change discourse in China by analysing how Chinese publics participate in the public discussion around two Intergovernmental Panel on Climate Change reports and how individual users interact with state and elite actors on the pre-eminent Chinese microblogging platform Weibo. Using social network analysis methods and a temporal comparison, we examine the structure of climate communication networks, the direction of information flows among multiple types of Weibo users, and the changes in information diffusion patterns between the pre- and post-Paris periods. Our results show there is an increasing yet constrained form of public engagement in climate communication on Weibo alongside China's pro-environmental transition in recent years. We find an expansion of public engagement as shown by individual users' increasing influence in communication networks and the diversification of frames associated with climate change discourse. However, we also find three restrictive interaction tendencies that limit Weibo's potential to facilitate multi-directional communication and open public deliberation of climate change, including the decline of mutually balanced dialogic interactions, the lack of bottom-up information flows, and the reinforcement of homophily tendencies amongst eco-insiders and governmental users. These findings highlight the coexistence of both opportunities and constraints of Weibo being a venue for public engagement with climate communication and as a forum for a new climate politics and citizen participation in China.

Keywords: climate change communication; China; public engagement; social media; social network analysis

2.1. Introduction

Since its 13th Five-Year-Plan period (2016–2020), China has undergone a pro-environmental transition and a restructuring of its economy for greener growth. China—currently the world's largest emitter of CO2, and seen as a 'laggard' in Copenhagen (Christoff, 2010)—has recently taken a more proactive role in the global climate regime (see Engels, 2018; Roberts, 2011). China pledged at COP21 to peak its emissions by 2030 and announced in 2020 to further strengthen its target to achieve carbon neutrality by 2060. Domestically, these pledges have translated into a series of rapid climate policies and state-led programs, such as policies and investments to boost renewable energies and the nation-wide "Energy Conservation and Emission Reduction" plan (State Council, 2011). Although China's climate responses remain largely insufficient to meet climate targets, these initiatives demonstrate a positive shift in China's environmental orientation. Some observers highlight the significant role of the Chinese central government in steering this pro-environmental transition. They attribute China's environmental turnaround to an authoritarian environmentalism model where a non-participatory approach bypasses public ignorance, conflicts of interest, and other factors that slow or hinder climate action (e.g., Beeson, 2018; Chen & Lees, 2018). However, recent studies have presented a more nuanced image of China's environmental governance. Internal contestations among governmental agencies, local authorities, and interest groups often exhibit a mixture of both liberal and non-inclusive features in China's multi-level climate governance (e.g., Lo, 2015; Schreurs, 2017). Public participation, in its various forms, is increasingly prevalent and effective in the practice of environmental policy processes (see Wu, Ma, Bian, Li, & Yi, 2020). Instead of relying on a strong state capacity to override contestation, successful environmental outcomes

are often a result of coordination among multiple stakeholders (e.g., Huang, Castán Broto, Liu, & Ma, 2018).

These important nuances in China's environmental governance show us the need to study China's climate governance as a complex and evolving process and to direct more attention to the interactions among state and non-state actors across different settings. In this study, we explore how such interactions among state, elite, and individual actors unfold in the climate change communication field. Specifically, this study asks: How do interaction patterns and information flows within the climate communication network reflect the dynamics between state actors and the public? What implications do these patterns have for the potential of Weibo to foster meaningful public engagement and deliberation on climate change?

Climate communication helps construct public imaginaries and promotes civic participation around climate change. It is an important arena in which climate change discourse is produced, reproduced, and transformed (Carvalho, 2010; Carvalho, van Wessel, & Maeseele, 2017). A proliferating body of literature discusses both the positive and negative roles of social media for online discursive interaction and offline action around climate change. However, despite the significance of China's actions (or inaction) in the global decarbonisation process and the increasing penetration of social media in Chinese society, little is known about the way in which climate change is communicated on Chinese social media and the degree to which these channels can be leveraged for public engagement in climate politics. This study looks into how climate communication is carried out on Weibo, a premier social media platform and an important space for public expressions in China. By analysing the structure of communication networks and the direction of information flows in public discussions about the Intergovernmental Panel on Climate Change (IPCC) Fifth IPCC Assessment Report (AR5; IPCC,

2014) and Special Reports on Global Warming of 1.5 ºC (SR15; IPCC, 2018), this study sheds light on the often black-boxed interaction processes among state, elite, and individual actors in building public discourse around climate change. Thus we contribute to a better understanding of both the potential and limitations of the Weibosphere for public engagement in China's new climate politics.

2.2. Literature Review

Public engagement with climate change is a multifaceted notion that comprises cognitive, affective, and behavioural dimensions (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007). Climate communication plays an important role in many of these facets. Communication helps to create discursive conditions for public engagement as it shapes people's perceptions of and attitudes towards climate change. Discursive interactions in climate communication also provide important venues for the construction of people's political subjectivity in acting on climate change (Carvalho, 2010; Carvalho et al., 2017). A core tenet of public engagement is the promotion of two-way information exchange that enable multi-perspective inputs and mutual-learning (Rowe & Frewer, 2005). Such multi-directional interactions are particularly important in addressing climate change. Being a complex issue situated at the intersections between ecological, economic, political, and social systems, its causes and impacts involve an extraordinarily diverse array of stakeholders. Climate mitigation and adaptation demand coordination between various motivations for (and barriers to) making changes (Baber & Bartlett, 2005). In light of this, a crucial objective of climate communication is to provide a public space in which actors can present, deliberate, and negotiate their diverse and sometimes contested interests around climate change (Stevenson & Dryzek, 2014).

A rich body of literature discusses how social media bring in opportunities for—and also challenges to—such multi-directional interactions in disseminating knowledge, shaping public perceptions, coordinating public engagement, and mobilizing political participation around climate change (e.g., O'Neill & Boykoff, 2012; Pearce, Brown, Nerlich, & Koteyko, 2015; Segerberg & Bennett, 2011). However, this body of literature has a noticeable geographical bias as it is largely based on developed Western societies, particularly the Twittersphere (Pearce, Niederer, Özkula, & Sánchez Querubín, 2019). In the Twitter context, climate communication has been studied from various perspectives, including user-centred research on information exchange, content-based research on themes and sentiments, and reflexive discussions about its technological, social, and political potentials (for a review, see Pearce et al., 2019; Schäfer, 2012). There is, as yet, only a handful of studies looking into how climate communication plays out on China's Weibo (e.g., Liu & Zhao, 2017; Riley, Wang, Wang, & Feng, 2016).

Although few Weibo studies are specified in climate communication, research on Weibo's role in civic communication is proliferating. As an important alternative space for public discourse in China, Weibo provides a conduit for presenting voices that were once absent from China's state-operated mass media system allowing them to be debated in public discussion. Even though this process is not free from political, market, or algorithm interference, it still introduces positive dynamics into state–society interaction in China (Gu, 2014; Lewis, 2013; Sullivan, 2013; Wang & Shi, 2018; Zhang & Lin, 2014). In the environmental field, many studies focus on civil society organizations to investigate how Weibo is leveraged to raise public environmental awareness, facilitate environmental advocacy, and mobilise (non-confrontational) civic action (e.g., Huang, Gui, & Sun, 2015; Zhang & Skoric, 2020). Researchers also note the positive translation of online public opinion to environmental policies. A good example is the

public debate over air pollution: ignited and escalated on Weibo, this nationwide debate made air pollution a highly visible issue on China's political agenda and eventually led to factory relocation and industrial reform (see Fedorenko & Sun, 2016). In this light, Weibo is often discussed as an enabling space for the environmental movement and a green public sphere (Liu, 2011; Sima, 2011; Yang, 2009) in China.

However, consistent with critiques of the rigidity of the Habermasian public sphere (e.g., Fraser, 1990), some scholars question whether the public sphere notion fits the complicated and dynamic reality of civic communication in China, where the boundary between state and society is often blurred (Huang, 1993). While many researchers cite censorship as the main reason to question Weibo's political potential, we caution that the interaction between the state and the public on Weibo is more complex than a simple oppression–empowerment dichotomy. The situation on the ground varies across different fields and different levels of political sensitivity. King, Pan, and Roberts (2013) showed that censorship is only limited to curtailing mobilisation of subversive collective action. Rauchfleisch and Schäfer (2015) also found multiple public spheres exit on Weibo and the one associated with environmental issues features a high degree of open criticism and has large-scale participation. In relation to the broader environmental governance, there is also a nuanced body of literature showing complex interplays between the central authority and local agencies (e.g., Lo, 2015), and between state actors and civil society (e.g., Wu, Chang, Yilihamu, & Zhou, 2017). Van Rooij, Stern, and Fürst (2016) observed that a host of new environmental actors has risen and diversified China's environmental regulatory landscape. Relatedly, scholars have also noted the increasing use of deliberative measures in China's environmental policy processes (Mol & Carter, 2006; Zhang, He, Mol, & Zhu, 2013). These nuances resonate with what He and Warren (2011) called the deliberative turn in China's

political development, where public feedback and participation are increasingly incorporated into governance practice.

These important nuances in China's environmental politics show the need to move beyond a binary view and to direct more research attention toward the interaction process among state, elite, and individual actors. This article explores such interaction processes in the important yet under-researched field of climate communication in China.

We focus on Weibo-mediated public discussions around the IPCC AR5 and SR15 reports. As significant milestones and structuring forces in the development of the international climate regime, IPCC reports are important drivers of media visibility and public debate over climate change (Broadbent et al., 2016). These documents are also important objects in the 'science-policy interface' of the global climate regime because they work to produce the consensus position on climate science and shape climate policy development (Howe, 2014). In the Twitter context, previous studies have examined the communication of IPCC reports on several aspects, including the dominant frames (O'Neill, Williams, Kurz, Wiersma, & Boykoff, 2015), topics and communities (Pearce, Holmberg, Hellsten, & Nerlich, 2014), the divergence and interaction between different communities (Holmberg & Hellsten, 2016), and scientific knowledge translation among stakeholders (Yagodin, Tegelberg, Medeiros, & Russell, 2016). Newman (2016) studied the spreading of IPCC AR5 on Twitter and found non-elite actors attracted the most attention in public discussions. His study suggested opportunities on Twitter for non-traditional voices to reach large audiences.

By contrast, in the Weibo context, Liu and Zhao's study (2017) on the public discussion around the Paris Summit presented a rather bleak picture for public engagement on Weibo. Based on the number of reposts, they argued climate communication on Weibo is dominated by

institutional actors, particularly state-owned media and government agencies. However, we argue that climate communication on Weibo is more nuanced than this image of institutional actors' domination. User influence on social media is a multifaceted notion that may not be sufficiently captured by a single indicator such as repost quantity. In this study, we extend previous research findings by investigating user influence from a relational perspective.

Using social network analysis (SNA) methods, we study public engagement in climate communication on Weibo by focusing on information flows and interaction processes among different types of users. Specifically, we ask the following questions: Who participates in the spreading of the AR5 and the SR15 reports on Weibo? To what extent does information flow in a top-down or bottom-up manner? What factors contribute to users' tendencies to participate in the AR5 and SR15 public discussions? We also include a temporal dimension in our analysis to compare the climate communication networks between the AR5 and SR15 periods. Since these two reports were respectively published before and after the pivot in China's environmental orientation, comparing these two periods can shed light on how public engagement has developed alongside China's pro-environmental transition. By offering an empirical assessment of the interaction structure between state, elite, and individual actors, this study contributes to the literature of climate communication and public engagement in China's new eco-politics.

2.3. Methodology

We collected publicly accessible Weibo posts containing the keyword 'IPCC 报告' (IPCC reports) within 16 months of each report's release (2013 September–2015 January for AR5 and 2018 October–2020 February for SR15). We only focused on original user-generated posts (AR5 n = 1709, SR15 n = 2505). Figure 2-1 illustrates the distributions of these posts over weeks. For

both reports, public attention was mostly concentrated within a short time immediately after their release. Nevertheless, both reports were discussed persistently over the 16-month timespan and re-attracted public attention with the subsequent publication of related documents.

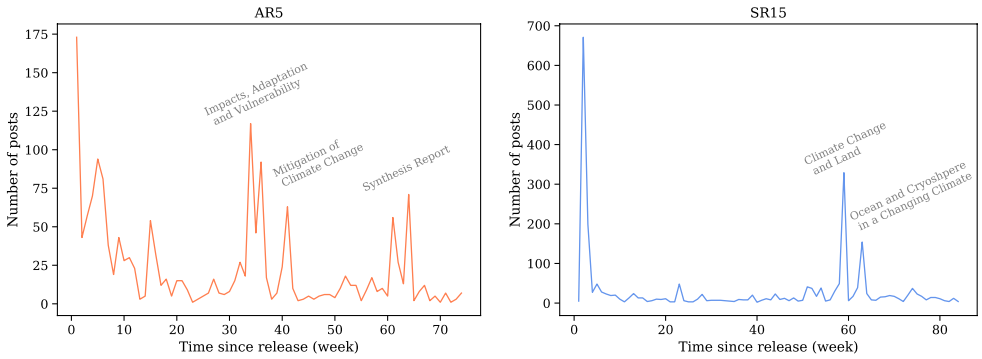


Figure 2-1 IPCC-related Weibo posts distribution by week since release.
Note AR5: 27 September 2013 to 30 January 2015; SR15: 8 October 2018 to 10 February 2020.

We used SNA to examine user interactions in public discussions on Weibo. SNA is a family of methods that draw on network and graph theory to investigate social structures. Unlike standard statistical techniques that reduce the social world to aggregates of discrete individuals and examine social behaviours as a function of individuals' attributes, SNA treats actors as 'agents-in-relation' and considers the effects of both individuals' attributes and the relational structure in which they are embedded (Crossley, 2011). Such a relational perspective is particularly useful for our study since information on social media is generated by users (agents) and travels through their online connections (relation).

We extracted all usernames involved in reposting relations and collected their publicly accessible user profile data. There were 316 such users in the AR5 period and 701 in the SR15 period. While these users only represent a very small fraction of the vast Weibosphere, they are nevertheless a meaningful sample for our relation-focused analysis because our primary interest is on users' interaction patterns rather than users per se. Based on users' reposting relationships,

we constructed directed and valued networks (as shown in Figure 2-2) to depict the structure of information dissemination, with nodes representing users, directed edges showing the directions of information flows, and edge values indicating the frequencies of reposting relationships.

Our examination consisted of two levels of analysis: We first descriptively analysed user demographics, the content of top posts, and network-level structures to provide an overview of public discussions. We then examined the structure of communication networks using exponential random graph models (Robins, Pattison, Kalish, & Lusher, 2007). As a statistical tool designed to tackle network data, exponential random graph models allows us to model the probability of relationships in networks as a function of both the individuals' social attributes and the network's structural properties. This helps us examine the structure of information flows between different types of users and identify the factors that affect their likelihood of spreading climate messages on Weibo.

Figure 2-2 Overview of AR5 network (left) and SR15 network (right).
Note. networks are in in ForceAtlas2 layout (Jacomy, Venturini, Heymann, & Bastian, 2014).

Specifically, we tested three groups of factors. The first two groups address the notion of elite-ness in climate communication. We used multiple factors in our models to represent its different conceptualizations. We distinguished three types of 'elite' users based on their digital social statuses (users were considered high digital social status if their follower sizes are above

the median of all sample users in the respective periods), interests in climate science or environmentalism (users were considered as science-affiliated or environmental concerned if their Weibo profiles contain related keywords), and account types (as indicated in Weibo's official verification system). The third group of factors explore two network structural effects that have particular implications for public engagement in climate communication.

To test these factors, we built three sets of exponential random graph models with three groups of hypotheses. The first group of hypotheses examines individuals' attributes. Since a higher status indicates a larger potential audience group on Weibo, we expected a positive effect of a larger follower size on both sending out and receiving climate messages: H1 users with a large number of followers are more likely to (a) be reposted and (b) repost others. We then tested the effect of being eco-insiders on users' reposting behaviour. Previous studies found internet use promotes citizen participation mainly among those who already have a high interest in or knowledge of relevant issues (see e.g., Min, 2010). We expected a similar positive effect in climate communication so that science-affiliated and environmentally concerned users would be more active than laypeople in obtaining and spreading climate messages: H2 science-affiliated users are more likely to be (a) information senders and (b) information receivers; H3 environmentally concerned users are more likely to be (a) information senders and (b) information receivers.

The second group of hypotheses examines the direction of information flows between individual users and four types of organizational users. Since China's climate responses are often seen as featuring a top-down character, we expected the same mechanism to be mirrored in the communication area so the AR5 and SR15 information would flow from organizational users to individual users: H4 organizational users, including (a) government, (b) media, (c) business, (d)

education, and (e) civil society organizations, are more likely to be information providers for individual users. We also tested whether there is a bottom-up information diffusion pattern: H5 individual users are more likely to provide information for organizational users, including (a) government, (b) media, (c) business, (d) education, and (e) civil society organizations.

The third group of hypotheses explores two types of network effects. The first is a pair-wise propensity: H6 users tend to form mutually balanced communication relationships by reposting those who have reposted themselves. This mutually balanced form of interaction is important to foster mutual-learning in climate communication. The second network influence is the homophily effect. Homophily describes people's tendency to interact mostly with those who are similar to themselves (McPherson, Smith-Lovin, & Cook, 2001). This effect has particular relevance in climate communication as it may limit individuals to selective information sources, thus creating echo-chambers which lead to opinion segregation and polarization (see, e.g., Jang & Hart, 2015). Previous studies revealed that strong homophily exists between climate activist and sceptic groups on Twitter and that this escalates partisan polarization over climate policies, as illustrated in U.S.-oriented research (Carmichael, Brulle, & Huxster, 2017; Williams, McMurray, Kurz, & Lambert, 2015). Within the Chinese context, our primary interest was the potential cleavage between the state/elite actors and the general public, so we tested whether a homophily effect exists among eco-insiders and various institutional users: H7 there is a statistically significant homophily effect amongst eco-insiders (i.e., environmentally concerned and science-affiliated users) and H8 there is a statistically significant homophily effect amongst organizational users, including those from (a) government, (b) media, (c) business, (d) education, and (e) civil society organizations.

Since our primary interest in this part of the analysis is the structure of information flows rather than the strength of users' relationships, we dichotomized the communication networks based on the presence (1) or absence (0) of the reposting relationship between user pairs. Self-loops were also excluded as reposting oneself has little meaning for information diffusion. Models were estimated using the R package 'ergm' (Hunter, Handcock, Butts, Goodreau, & Morris, 2008).

2.4. Results

2.4.1. Expansion of Public Engagement: Scale, Participants, and Network Overview

From the AR5 to the SR15 period, more people participated in public discussion and actively engaged in interactions with others, as well as more diverse frames associated with climate change on Weibo. We saw increases in the average numbers of reposts (from 12.54 in AR5 to 18.61 in SR15), comments (5.46 to 16.93), and likes (4.44 to 26.91). The portion of non-monologic posts (i.e., those with at least one reposting) also increased from 16.96% in AR5 to 26.63% in SR15. We also examined the content of the top 1% most widely circulated posts in each period (AR5 n = 17, SR15 n = 25). Figure 2-3 shows the themes which emerged from these top posts. We found early discussions focused on describing and understanding climate change, including news about the release of AR5, the projected climate scenarios, global impacts, infographics, and debates over settled versus uncertain science. This is consistent with Liu and Zhao's (2017) study, which found that Weibo discussions during the Paris Summit period were primarily about raising public awareness, and climate change was mostly presented as a global threat with little relevance to China's national context. However, we saw new developments in the SR15 period. Themes in SR15 discussions became more specific, argumentative, and domestically oriented, covering issues such as the impact on local environments and livelihoods,

the urgency of mitigation and adaptation action, low-carbon development for national interests, and debate over developed countries' historical carbon debts.

Table 2-1 compares the network-level descriptive statistics between AR5 and SR15, which shows more detailed changes to communication networks. As indicated by the larger numbers of nodes, edges, diameter, and average path length, the SR15 network had more participants, more reposting relations, and longer information diffusion chains than the AR5 network. However, three vital changes can be observed beneath this overall expansion pattern. First, the intensity of interactions decreased from the AR5 to SR15 period as the network density dropped from 0.31% to 0.14%. Second, the contradiction between the increased average degree and the decreased average weighted degree indicates that while individual users may interact with more people on average, they were less likely to interact recurrently or maintain their relationships over time. Third, as shown by the decrease in modularity, the SR15 network had fewer closely-knit clusters and presented a flatter structure than the AR5 network. Together, these network-level changes show that expansion of the network's scale did not bring a proportionate growth in interaction intensity. While the communication networks expanded from the AR5 to SR15 periods, interactions on networks became less dense, less recursive, and less clustered.

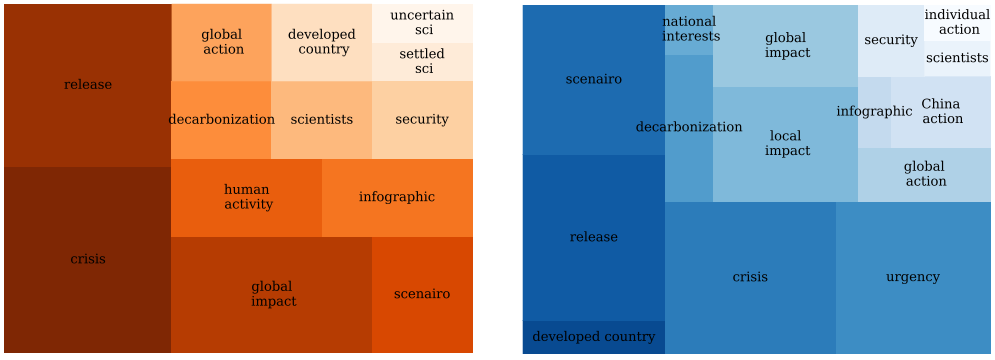
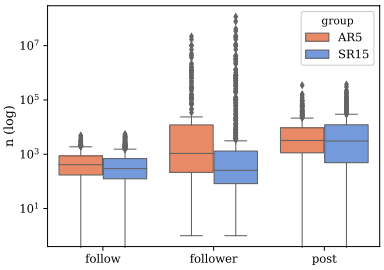


Figure 2-3 Content themes in the top 1% most circulated posts in the AR5 period (left) and the SR15 period (right).

Note. A larger square size indicates a higher theme frequency. A darker colour indicates a larger total repost number. A post may contain multiple themes.

Table 2-1 Network-level descriptive statistics of the AR5 and SR15 communication networks.

	AR5		SR15	
General Structure				
n of edges	312		694	
n of nodes	316		701	
avg. degree	0.81		0.91	
avg. weighted degree	1.34		1.26	
density	0.31%		0.14%	
diameter	5		7	
avg. path length	1.79		2.24	
modularity [a]	0.87		0.76	
User Profile	n	%	n	%
environmentalist	48	15.18%	49	7.08%
science-related	71	22.46%	43	6.21%
official verification	133	42.08%	147	21.24%
developed area	116	36.7%	231	33.38%
underdeveloped area	31	9.81%	82	11.84%
online social status				
Central Nodes [b]	*weighted degree*	*betweenness*	*weighted degree*	*betweenness*
state/elite	30%	25%	20%	5%
public individual	25%	45%	65%	85%



Notes: [a] Modularity using the Louvain algorithm (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008); [b] The top 20 nodes by centralities.

Another important trend identified by the network-level comparison is the popularization of climate communication on Weibo. The shares of eco-insiders, users located in China's wealthy developed areas, and those with higher online social statuses dropped significantly from the AR5 to SR15 period. Conversely, there was increased engagement by users from the lay public, underdeveloped regions, and those with lower online social statuses. The popularization trend is

also reflected by the rising influence of individual users. We consider users as influential if they reached a large audience (measured by weighted degree centrality) or bridged information flows between many others (measured by betweenness centrality). Focusing on the top 20 nodes with the highest weighted degree and betweenness centralities, we found more individual users became influential in the SR15 period whereas the share of elite users (e.g., governmental organizations, state-run media, people with official backgrounds) in these central positions dropped significantly over time. Overall, we saw that more individuals from the general public participated in information diffusion and had more opportunities to reach or bridge large audiences in the SR15 network.

2.4.2. Limitations to Public Engagement: The Direction of Information Flows

While the analysis above shows a general expansion of public engagement, a more nuanced picture emerged when we used exponential random graph models to examine interaction processes and information flows between state, elite, and individual users. The modelling results are provided in Table 2-2. All models successfully converged and fitted the data well (see the Supplementary File for goodness-of-fit and convergence statistics).

Table 2-2 Exponential random graph models results of the AR5 and SR15 communication networks.

	Model 1		Model 2		Model 3	
	AR5	SR15	AR5	SR15	AR5	SR15
Individual Terms						
fans_large (in)	-1.26*** (0.25)	-1.39*** (0.23)				
fans_large (out)	0.59*** (0.15)	1.23*** (0.11)				
science (in)	0.77** (0.24)	-0.49 (0.40)				
science (out)	0.21** (0.07)	2.18*** (0.08)				
enviro (in)	-0.13 (0.29)	0.78** (0.27)				
enviro (out)	0.2** (0.08)	-0.06 (0.16)				

Dyadic Terms						
reciprocity	3.47*** (0.43)	1.03 (1.09)				
top-down flow						
civil			0.32** (0.12)			
edu				0.78** (0.25)		
gov			0.03 (0.16)	-0.03 (0.21)		
media			0.29* (0.12)	3.44*** (0.08)		
bottom-up flow						
civil			-0.93† (0.52)			
edu			0.65 (0.74)	-2.03*** (0.55)		
gov			0.04 (0.38)	-2.50*** (0.34)		
media			-0.66 (0.43)	-2.17*** (0.54)		
homophily						
insider					0.41* (0.17)	1.77*** (0.19)
laypeople					-0.31* (0.12)	-1.95*** (0.09)
civil					2.25** (0.75)	
gov					1.42† (0.78)	1.65*** (0.38)
media					2.09*** (0.63)	0.15 (0.75)
individual					-0.02 (0.26)	-0.28 (0.20)
Baseline						
edges	-4.79*** (0.23)	-7.47*** (0.15)	-4.39*** (0.14)	-7.00*** (0.10)	-4.21*** (0.56)	-5.50*** (0.29)
in-degree (1)	2.07*** (0.17)	2.85*** (0.15)	1.83*** (0.14)	2.77*** (0.12)	1.84*** (0.14)	3.32*** (0.15)
out-degree (0)	5.98*** (0.46)		6.59*** (0.43)		6.33*** (0.45)	
out-degree (1)	3.79*** (0.38)		4.11*** (0.37)		3.96*** (0.38)	
Model Fit						
AIC	3226	8448	3327	8199	3304	7913
BIC	3331	8548	3432	8288	3438	8023

Notes: † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.00$. There were not enough observations of interactions between individual users with the civil society organization group in the SR15 period and the education group in AR5, so their corresponding dyadic terms were dropped in Model 2 and Model 3. Two out-degree controlling terms were added in AR5 models to better fit the data and improve model convergence.

In Model 1, we examined the interaction pattern of three types of elite users, including those with high online social status (H1) and those involved in climate science (H2) or

environmentalism (H3). We found different types of elite users played different roles in information diffusion. First, in both AR5 and SR15 networks, those with large numbers of followers were always more likely to send information to, and less likely to receive information from, users with a small number of followers. Second, eco-insider's roles changed over time: Science-affiliated users, who tended to be active in both sending and receiving information in the AR5 period, were less active in receiving information in the SR15 period. By contrast, while environmentally concerned users tended to be information providers in the AR5 period, they took on more of an audience role in the SR15 period as they became more active in receiving information.

In Model 2, we examined the direction of information flows between organizational users and individual users (H4 and H5). We found the diffusion of climate change information on Weibo tended to follow a top-down pattern. As the second block of Table 2-2 shows, while individual users tended to receive information from civil society organizations in the AR5 period, educational organizations in the SR15 periods, and media organizations in both periods, none of the organization types tended to obtain information from individual users. In the SR15 network, there were even fewer bottom¬-up flows from individual users to education, governmental, or media users than one would expect by chance. Overall, we found the top-down pattern of information diffusion was reinforced over time and individual accounts became less likely to be reposted by organizational accounts in climate communication on Weibo. However, this top-down trajectory shows a divergence from Liu and Zhao's previous study (2017), which found that governmental and media users dominated climate communication on Weibo. Our network analysis shows governmental users were not influential information providers for individual users. Instead, only the media users (including mainstream, private, and independent types)

played a significant role in spreading information to individual users in climate communication on Weibo.

Model 3 tests two network effects. We found the reciprocity effect (H6) was statistically significant only in the AR5 period. The decrease of mutually balanced relations signals a recent decline in interactive conversations in climate communication on Weibo. This may reflect a broader shift of interaction patterns on Weibo towards spreading messages rather than promoting dialogue and opinion exchange. When testing homophily effects, we found eco-insiders (H7) tended to communicate in more closed circles amongst themselves in both periods, whereas users from the general public were more likely to jump out of their circle and obtain information from eco-insiders. We saw a low risk of information cleavage for most organizational types except for governmental users (H8). While there was a homophily tendency within civil society and media organizations in the AR5 period, it was no longer statistically significant in the SR15 period. However, governmental users' homophily tendency was reinforced over time. Since closed communication circles often lead to information cleavage, reinforce people's existing opinions, and exacerbate divergences between groups, the homophily tendencies amongst eco-insiders and governmental users may obstruct them from participating in meaningful public deliberation on Weibo. Furthermore, we noted a hierarchical pattern among governmental users. Figure 2-4 shows an example from the SR15 network. Within this governmental users' cluster, information flows hierarchically from the Ministry of Ecology and Environment to provincial- and lower-level local environmental protection bureaus, then to subsidiary public organizations and non-state actors. This hierarchical chain provides an example of how a top-down form of environmentalism manifests itself in the communication domain.

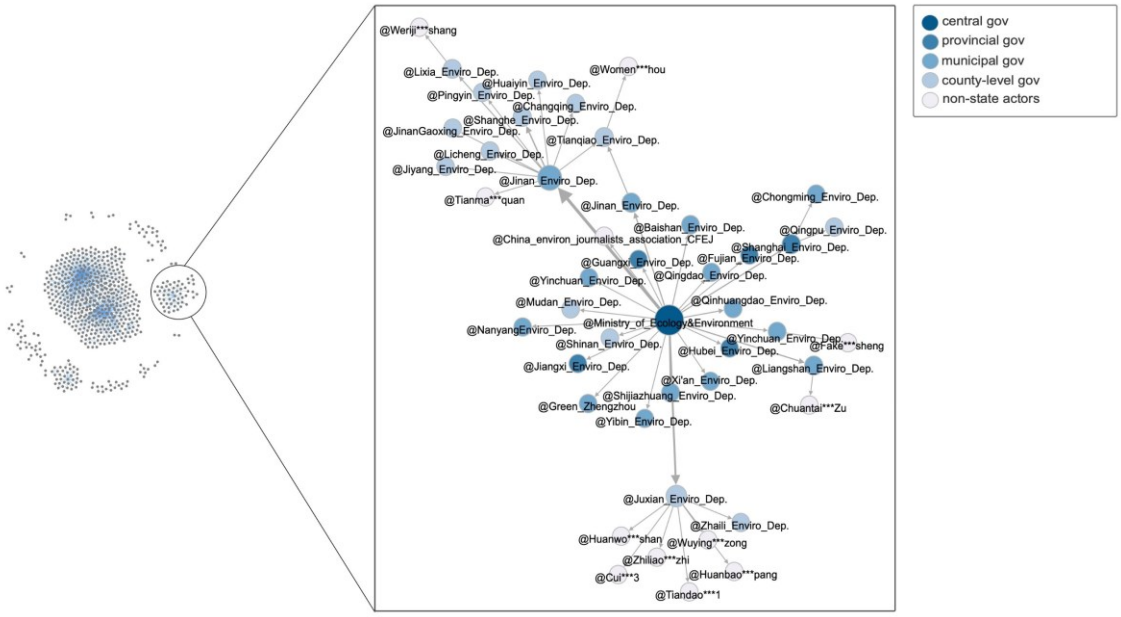


Figure 2-4 A hierarchic governmental user cluster in the SR15 network.
Note. Left: the whole SR15 network. Right: a governmental user cluster. Node sizes indicate weighted degrees; node colours indicate hierarchic levels; edge arrows show the directions of information flow. Non-state actors' usernames have been anonymized to protect privacy.

2.5. Discussion

Our findings show both opportunities and limitations for climate communication on Weibo alongside China's pro-environmental transition in recent years. From the AR5 to SR15 period, there was a general expansion of public engagement and popularization trends in climate communication on Weibo, as shown by the increased number of participants, diversified climate change frames, and increased influence of individual users in bridging information flows. We examined users' dominance from a relational perspective and found that non-elite individual users became more influential in climate information diffusion on Weibo. Our exponential random graph models results provide more nuances to the general popularization trend. Firstly, we found information flows in climate communication on Weibo largely followed a top-down pattern. Media accounts were the most prominent information source for individuals, whereas the

governmental users' role to individual users was not significant. Secondly, among the three types of elite users studied in our models, only the environmental user group showed a high probability of obtaining information from the general public users. Those with more followers and those affiliated with climate science tended to play the role of information sources in climate communication. We also found several trends that limit Weibo's potential for facilitating multi-directional public engagement in climate communication, including the decrease of interaction intensity, the decline of mutually-balanced dialogues, the reinforcement of top-down diffusion pattern, and persistent homophily tendencies amongst eco-insiders and governmental users.

These findings present a mixed picture of the interaction process among state, elite, and individual actors, which helps us to reconsider Weibo's role in climate communication. Social media's potential for public engagement and political participation derives from the interactivity and connectivity embedded in their techno-social infrastructure. While interactivity enables people to be engaged in multi-directional opinion exchanges and public deliberation, connectivity generates 'mediated public connection' (Couldry, Livingstone, & Markham, 2007) that allows fragmented individual conversations, experiences, and beliefs to be consolidated into public discourses and collective values. Despite the theoretical potential, the degree to which interactivity and connectivity translate into opportunities for public engagement varies across different contexts. First, we have to ask who the public are: The actors that constitute 'the public' in climate politics are not a homogenous or unified whole (Whitmarsh, O'Neill, & Lorenzoni, 2013). Instead, there are a nexus of multiple publics (Fraser, 1990) who interpret climate change, each with their own vested interests, perceptions, and 'cultural competencies' (Burgess, Harrison, & Maiteny, 1991). Second, complexity also arises from the structure of interactions. While some interactions create bridging and bonding opportunities that translate connectivity into social

capital, other interactions produce restrictive structures. Therefore, in our analysis, we first distinguished Weibo users by their types, online social status, and their interest or involvement in climate science and eco-protection. We then examined the structure of their interactions and the direction of information flows in this structure to discuss Weibo's potential to facilitate open and multi-directional communication. Our empirical results presented the process and complexity in Weibo interaction from a relational network perspective, thus contributing to the ongoing debate about both the potential for and limitations of leveraging social media for public engagement with climate change.

Our analyses show both enabling opportunities and constraining conditions on Weibo. While we do find signs of Weibo's democratizing potential as a green public sphere (Yang, 2009), we also see how greater participation may not translate into political efficacy in terms of the ability of citizen voices to reach elite state actors. Such a coexistence between the expansion of public engagement and the top-down information diffusion pattern in climate communication resonates with the notion that the Chinese political sphere is undergoing a shift, becoming more 'responsive' (Mertha, 2009), where public participation is increasingly incorporated into environmental governance, but public participation does not challenge the centrality of state elite actors. This mixed image suggests that Weibo does not necessarily lead to a more autonomous or bottom-up climate politics, but neither does it simply maintain official and elite users' dominance in shaping the public discourse of climate change. This two-sided image highlights the limitation of viewing Weibo as a normative Habermasian public sphere in China's eco-politics. China's environmental movement and governance are characterised by an interpenetration between the state and the civil society (Ho & Edmonds, 2007). Therefore, to better understand China's climate politics, we have to move beyond a dualistic view that rests on a binary opposition

between state and civil society, and direct more attention to the processes through which state and civil society interact, as well as their contexts and dynamics.

This study is subjected to several limitations. First, the size of the dataset we examined was limited by our choice to focus on public discussions around IPCC reports rather than climate change in general. Although studying this specific topic allows us to focus on the core conceptions of climate change, these event-triggered discussions cannot fully represent how climate change is discussed in everyday life. Future studies would benefit from a larger dataset that includes more issue- and theme-based public discussions to capture a more comprehensive picture of climate change discourse. Second, we measured users' influence by their degree of centrality in communication networks. While node centralities are important indicators of prominence in network analysis, users' influence in communication is nevertheless a multifaceted concept. Future research will benefit from incorporating other indicators to gauge different aspects of communicative influence. Relatedly, we focused on the process of information diffusion through sharing relationships. There are other important dimensions of communication. Particularly, future studies could focus on the ideational content in climate communication and the quality of deliberation by conducting an in-depth qualitative analysis of public discussions.

2.6. Conclusion

This article provides an empirical study of public engagement with climate change discourse in China by analysing the information flows among state, elite, and individual users in public discussions around two IPCC reports on China's prominent social media platform Weibo. Our results show there is an increasing yet constrained form of public engagement in climate communication on Weibo. We find public engagement expanded alongside China's recent pro-

environmental transition as individual users became increasingly influential in initiating public discussions and disseminating climate messages in communication networks. Relatedly, we observe a popularization trend of the climate change discourse as shown by the diversification of participants and frames in public discussions. Conversely, we found three restrictive interaction patterns that highlight the limitations of Weibo as a space for a new climate politics in China. First, the decline of mutually balanced dialogic interactions reduces Weibo's potential to facilitate meaningful public deliberation around climate change. Second, the lack of bottom-up information flows indicates a deficit of public feedback and input, which limits Weibo's potential for facilitating genuine multi-directional communication in public engagement. Third, closed communication circles amongst eco-insiders and governmental users may confine them to selective information and opinions, create cleavages between these elite users and the general public, and thus obstruct mutual-learning and open opinion exchange in climate communication.

3. Chapter 3 Analysing the Convergence of Environmentalism and Development in Online Climate Change Discussions on China's Weibo (2009–2019)

1.2 Abstract

This study investigates the dynamics of online climate change discussions on China's top social media platform Weibo between 2009 and 2019. Drawing on the theoretical concept of developmental environmentalism, we analyse whether and how the Chinese public's climate discussions on Weibo are framed through a development-oriented discourse. This discourse underscores the convergence between environmental protection and national development as catalysts for pro-environmental actions, green energy transition and low-carbon development. Specifically, we employ topic modelling and network analysis to examine development- and environmentalism-oriented climate change topics' public visibility on Weibo, the network structure of their co-occurrence relationship in individuals' online expression, and their temporal evolution in terms of diagnostic, prognostic, and motivational framings of climate change. Our findings reveal two significant insights. First, pronounced and close interconnections exist between environmentalism and development topics in the Chinese public's online climate change discussions on Weibo. Second, while environmentalism topics tend to be more expansive, development topics exhibit a higher degree of network centrality, thus attaining greater prominence in the online public discourse. These results suggest that the Chinese public on Weibo embraces a non-dichotomous understanding of the interplay between environmentalism and developmental goals where climate change is concerned. Recognizing the prevalence of developmental environmentalism in public discourse helps us better understand China's pro-environmental initiatives and proactive climate change measures in recent years.

Keywords: climate change, developmental environmentalism, public discourse, China, topic modelling, Weibo

3.1. Introduction

Climate change is a global social-ecological crisis, but its ecological and social impacts are embedded in national and local historic, social, and political contexts (Boykoff, 2011; Hulme, 2009; Olausson & Berglez, 2014; Schäfer & Schlichting, 2014). Promoting meaningful local climate actions requires us to grasp the nuances of climate change discourse in specific contexts. As the global climate policy architecture is increasingly fragmented, complex, and decentralized in the post-Copenhagen Climate Summit (2009) era (Bäckstrand & Lövbrand, 2019), studying localized variations of people's understandings and perceptions of climate change issues becomes particularly important. Moreover, the formulation of solutions to environmental challenges hinges on how the issues are defined in the first place (Nisbet, 2009), which also shapes our visions for sustainable futures (Stoddart, McLevey, Schweizer, & Wong, 2020). Therefore, it is necessary to study how climate change issues are perceived and communicated across different socio-political contexts. We contribute to this body of the literature by investigating an important yet under-researched case — China.

Since becoming the world's largest CO2 emitter in 2006, China's approaches in response to climate change have been characterized by intricate nuances and unexpected turns (see e.g., Ma, 2019; Zinda, Li, & Liu, 2018a). On one hand, China has made noteworthy progresses in addressing climate change. This is evident in the implementation and growing momentum of significant environmental and climate policies, such as substantial investments in the renewable energy sector, the swift decommissioning of domestic coal-fired power plants, and ambitious

national afforestation and ecosystem sequestration projects. However, the country also grapples with formidable obstacles to decarbonization. Challenges persist in the form of reliance on carbon-intensive energy sources, its industrial production and consumption infrastructure, and the political imperative for GDP growth. China's role in global climate politics is also complex. Once seen as a laggard in climate mitigation or even a "deal blocker" in the Copenhagen summit (see e.g., Lynas, 2009), China's position in international climate negotiations has seen significant changes between 2009 and 2019. Ambitious targets such as the "dual carbon goal" (i.e., peaking CO_2 emissions before 2030 and achieving carbon neutrality by 2060) seem to indicate the country's increasing interest in taking on a leadership role in the "fragmented global climate regime" (Roberts, 2011). Complexity also arises as China's responses to climate change are often bundled up with other national priorities, including alleviating air pollution, economic reform, energy and natural resources security, geopolitical interests, as well as the desire to project the national image of "a responsible major country" (The State Council Information Office, 2021). This convergence of interests not only reflects but also contributes to the complexity and multiplicity of Chinese climate discourse.

Our analysis draws on theoretical concepts of developmental environmentalism (S.-Y. Kim & Thurbon, 2015; Thurbon, Kim, Tan, & Mathews, 2023), new developmentalism (Dent, 2018), and a range of works that discuss the alignment between environmental protection and national development in motivating pro-environmental actions, green energy transition and low-carbon development in Asian countries (H. Han, 2017; Mathews & Tan, 2015; Tan, Thurbon, Kim, & Mathews, 2021). This body of literature contends that recent environmental transitions observed in countries such as Korea and China should not be understood as merely motivated by environmentalist objectives. Instead, they are anchored in a historical developmentalist trajectory

of these countries' policymaking processes. Central to developmental environmentalism is the proposition that environmental and developmental goals are not just interdependent by nature, but they can be effectively synergized through the advancement of green technologies and industries in practice (S.-Y. Kim & Thurbon, 2015, p. 215). This discourse presents a different view from the normative interpretation of sustainable development, whose emphasis on the reconciliation between economic growth and ecological conservation often implies an underlying tension and a need for balance rather than inherent compatibility between the two goals (see also Dent, 2018).

The concept of developmental environmentalism offers a valuable framework for studying China's proactive climate policies in recent years. As China undergoes a pivotal economic shift from being the "world's factory" to cultivating a high-value-added economy, developing green technologies and investing in the renewable energy industry presents a strategic opportunity for economic development rather than a threat. The push toward this green transition serves a dual purpose for China: it not only helps to address the vital environmental pollution issues like smog and water pollution that harm the well-being of its citizens, but also propels China to the forefront of the next wave of green techno-industrial innovation at a time when global energy demands are increasingly moving away from fossil fuels. Domestically, the drive towards the green economy expands industrial capacity, stimulates job creation, and spurs technological innovation in emerging industries. Internationally, advancing export competitiveness in the green technology sector could contribute to greater geopolitical influence and soft power, especially among countries engaged in the Belt and Road Initiative. Through the lens of developmental environmentalism, China's climate initiatives can be understood as not merely a reactive measure to domestic environmental challenges or international pressure, but as a proactive,

calculated, and future-oriented component of the comprehensive strategy for the country's long-term political-economic development.

Drawing on the notion of developmental environmentalism, this study investigates whether and to what extent climate change issues are shaped and represented through the developmental environmentalism frame in online public discourse between 2009 and 2019. We focus on the public discussion on one of China's largest social media platforms Weibo. Specifically, we combine computational text analysis and network analysis to examine development- and environmentalism-oriented climate change topics in terms of their public visibility on Weibo, the network structure of their co-occurrence relationship in individuals' online expression, and their temporal evolution in terms of the diagnostic, prognostic, and motivational framings of climate change. Overall, we find that the developmental and environmental orientations of climate change present a close association in Weibo discussion, indicating the pervasiveness of developmental environmentalism discourse in relation to climate change issues within the Weibosphere.

3.2. Literature Review

Discourses and frames not only serve as meaning-generating and -screening devices but also shape individuals' experiences and direct their actions (Hulme, 2009; Nisbet, 2009; S. D. Reese, Gandy Jr, & Grant, 2001; Shove, Pantzar, & Watson, 2012; Snow & Benford, 1988). A rich body of literature has emphasized the significance of examining how environmental issues are discursively framed and portrayed, studying their roles in shaping policy formulation and implementation, and analysing the intricate power dynamics in these processes (e.g., Castree & Braun, 1998; Dryzek, 2005; Hajer & Versteeg, 2005; Hansen, 1991; Vesa, Gronow, & Ylä-Anttila, 2020). Climate change discourse, in particular, is characterized by a multitude of diverse

and often contested "interpretive packages" (Entman, 1993) that elicit distinct understandings, propagate divergent visions for socio-ecological futures, and support (or impede) different courses of action in response to climate change (e.g., Ecker et al., 2020; Fünfgeld & McEvoy, 2014; McCright & Dunlap, 2011; Myers, Nisbet, Maibach, & Leiserowitz, 2012; Spence & Pidgeon, 2010). Extensive scholarly attention has been devoted to exploring the processes of meaning-making, framing, and reframing of climate change and its impacts (for a general review, see Moser, 2016; Schäfer & Schlichting, 2014; Shanahan, 2021). Nevertheless, in contrast to the wealth of research conducted in Anglophone and European contexts, the representation of climate change discourse in China remains relatively understudied.

Examining the discursive presentation of climate change in China can help to illuminate the trajectory of the country's way to address climate change. The literature reflects different perspectives regarding the dominant way(s) in which climate change is constructed as a social-ecological problem in China. Some scholars contend that Ecological Modernization (Christoff, 1996; Jänicke, 2008; Mol & Spaargaren, 2000) serves as a guiding framework for China's environmental governance and offers a lens through which to address climate change in China (e.g., Mol, 2006, p. 201; Riley, Wang, Wang, & Feng, 2016; Zhang, Mol, & Sonnenfeld, 2007). Ecological Modernization, in its broad context, emphasizes technological innovation and enhanced resource efficiency as key environmental solutions and underscores the collaborative eco-political processes involving states, businesses, and civil society, wherein individuals play an important role as both citizens and consumers (Christoff, 1996; Jänicke, 2008; Mol & Spaargaren, 2000). Consequently, the Ecological Modernization framework is often characterized as a reformist, rather than radical, approach to eco-politics, presupposing the potential for achieving a more sustainable global capitalism (Dryzek, 2012).

On the other hand, some researchers argue that the Chinese climate discourse is characterized by a diverse array of (and sometimes conflicting) discursive elements — alongside the globally prevailing discourse of Ecological Modernization, there is notable inclusion of perspectives that underscore national interests, the notions of Scientific Development and low-carbon economy, and eco-socialism (Ellermann, 2013; Tseng, 2015; S. Wang, 2018; Wang-Kaeding, 2015; Y. Zhang & Orbie, 2021). These additional dimensions contribute significantly to the formulation and evolution of discourses surrounding climate change and environmentalism within the Chinese context. Wang-Kaeding (2015) posits that the localization of global green norms has led to a fragmented discourse in China's environmentalism. Transnational notions like sustainable development have become intertwined with China's cultural tapestry that encompasses traditional Confucian and Taoist heritage, as well as Marxist-Leninist and Maoist legacies, leading to the formation of the made-in-China "grand discourse" of *Ecological Civilization* (Wang-Kaeding, 2015, pp. 34-37). Central to the envisioned future of Ecological Civilization is the notion that, through scientific and technological progress, an eco-socialist ethical foundation can guide the country's economic growth in a sustainable manner while steering clear of the exploitative trajectory of the preceding capitalist era, fostering a harmonious balance between nature and humanity (see e.g., State Council, 2015b).

Despite these divergent views, many studies consistently find that national development stands out as a prevailing theme in China's environmentalism and discourse on climate change. For example, Pan, Opgenhaffen, and Van Gorp (2021) find that development concepts have significantly influenced the evolution of climate change discourse in China's state media *People's Daily*: While the attitude has changed from viewing climate action as a barrier to an

opportunity for sustainable economic growth, the newspaper's emphasis on economic growth and technology advancement in its climate coverage remains persistent throughout the time between COP1 and COP24 (1995–2018) (Pan et al., 2021, p. 195). Beside state media, development-related themes are also prominent in other types of media outlets that represent non-official and diverse perspectives in China. For instance, Wang (2018) examines the climate coverage in *People's Daily* (targeting domestic readers), *China Daily* (China's official English-language newspaper for international readers) and *Southern Weekend* (a commercial media outlet) and identifies development as one of the three dominant discourses that are consistently employed by these three different types of media outlets in framing climate change issues. Studies also find that development emerges as an important theme in China's official policy discourse of Ecological Civilization. For instance, Hansen, Li, and Svarverud (2018) argue that the socio-technical imaginary of Ecological Civilization is characterized by a model of continued growth in production and consumption that is facilitated by advancements in technology and science and orchestrated under the leadership of the Party-State (p. 201).

Much of this body of research is based on media coverage and official policy documents. However, climate change is a complex issue involving diverse actors across various societal sectors. The reliance on elite and official perspectives, primarily emanating from political circles or mediated by media professionals, falls short of capturing the broader picture of the Chinese people's understandings of climate change and its impacts. While numerous studies have emphasized the Party-State's dominance in influencing climate change discourse in China (e.g., Eberhardt, 2015; J. Han, Sun, & Lu, 2017; Pandey & Kurian, 2017), recent research has increasingly focused on the nuanced interplay between state power and other societal actors in co-producing narratives and dynamic information flows related to climate change issues in China

(e.g., Riley et al., 2016; Y. Yang & Stoddart, 2021). To gain a better understanding of the Chinese climate discourse in a broader context, our study focuses on the public climate discussion on social media — a more openly accessible realm for climate change communication (for a general review on social media-based climate communication, see Pearce, Niederer, Özkula, & Sánchez Querubín, 2019). Several studies have investigated this public space in relation to climate change in China (e.g., J. C.-E. Liu & Zhao, 2017; Riley et al., 2016; Y. Yang & Stoddart, 2021). However, these previous studies mostly focus on brief periods of time (particularly during major climate events or COP summits), examining only a small group of pre-selected participants, and relying on manually coded content analysis. There is a clear need in the literature for a more systematic exploration of broader public discussions. Particularly valuable would be an analysis that tracks the evolution of public discussions about climate change, as studies have found noticeable shifts exist in China's climate discourse over time (e.g., Pan et al., 2021). To bridge these gaps, our study employs computational text analysis and social network analysis techniques to analyse a large dataset of climate change conversations on Weibo spanning from 2009 to 2019.

3.3. Methodology

3.3.1. Data and Pre-processing

We collected 367,535 original and publicly accessible Weibo posts containing the keywords "*气候变化*" (climate change) and "*全球变暖*" (global warming) posted between August 16, 2009[3] and December 31, 2019. Initial data cleaning involved the exclusion of duplicate and highly similar posts to mitigate the noise from marketing or clickbait accounts who

[3]Weibo was initially launched in late 2009. The earliest available data dates back to August 16, 2009.

often repeatedly posting similar content. We do so by identifying groups of posts with highly similar content[4] and removing posts with redundant information in each group. This screening process results in a refined dataset comprising 237,222 posts. Figure 3-1 depicts the daily average number of posts in this dataset, from which we can see a notable increase in Weibo posts related to climate change over years. Specifically, the period between 2012 and 2015 stands out, signifying a heightened public interest in climate change issues during this period. Subsequently, we extracted the textual content from these posts to build a corpus. Before using the corpus to train the topic model, we undertook several preprocessing steps, including segmenting Chinese language sentences into space-separated word sequences[5], eliminating stop-words, normalizing terms and phrases, as well as conducting tokenization and vectorization.

[4] The python library *string_grouper* (van den Berg, 2021) was used to help us identify groups of posts with highly similar content. *string_grouper* uses TF-IDF with N-Grams as terms to calculate cosine similarities among texts (van den Berg, 2021). For each group of posts whose content has a cosine similarity score over 0.9, we only kept one post in our dataset and removed the rest.

[5] The python library *jieba* (J. Sun, 2020) was used to implement Chinese text segmentation.

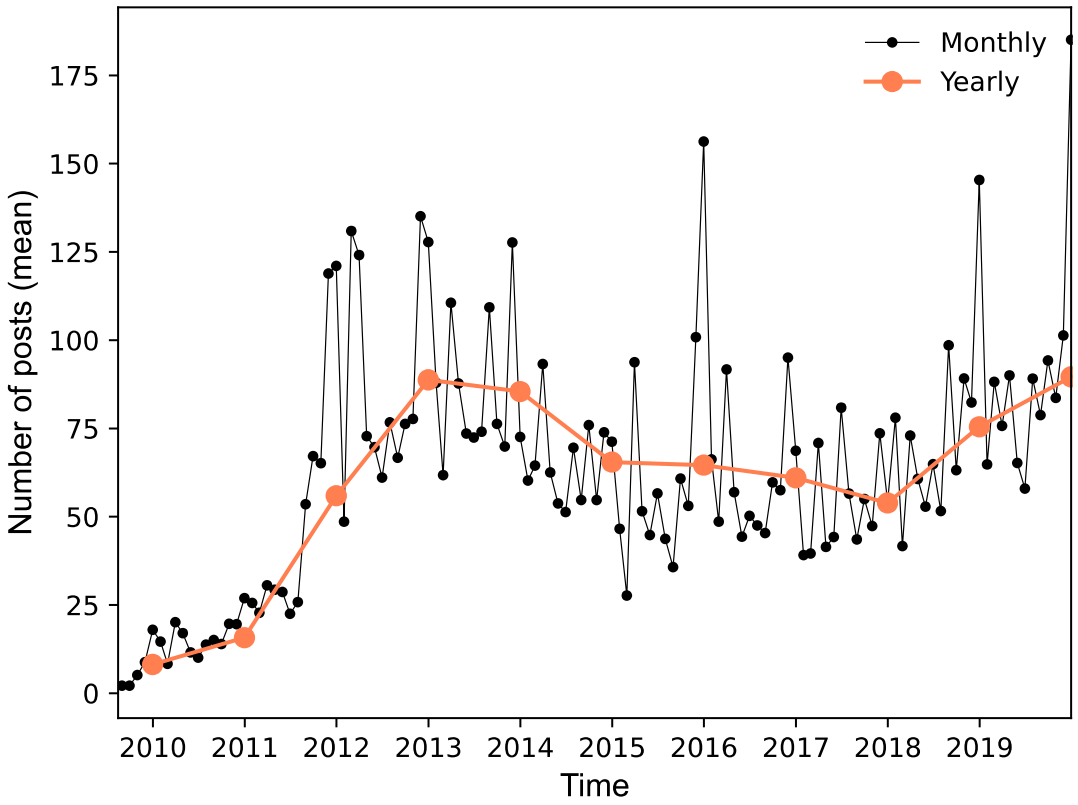


Figure 3-1. The average number of climate change-related Weibo posts per day (2009–2019). *Note*. Data is downsampled into monthly and yearly bins. Posts with highly similar content are excluded.

3.3.2. Topic Modelling and Topic Network Analysis

There are three analytical components in our analysis. The first focuses on identifying major topics in public discussions using unsupervised topic modelling method. As a computational text mining and natural language processing technique, topic modelling can be used to reveal the latent semantic structure (i.e., topics) in a large volume of unstructured text documents through modelling the hierarchical probabilistic relationship of word co-occurrence (Blei, Ng, & Jordan, 2003). This study utilized Correlated Topic Modelling (CTM) (Blei & Lafferty, 2007) to analyse the Weibo climate change corpus. CTM extends the classic LDA

algorithm by sampling topic mixtures from a more flexible logistic normal distribution rather than a Dirichlet distribution, thus allowing models to account for topics' prior correlations in documents (Blei & Lafferty, 2007). This method is well-suited for our data as we expect individuals' Weibo discussions may often involve a mixture of topics because of the multifaceted and comprehensive nature of climate change discourse. The fitting process for our models was implemented using the R package *stm* (Roberts, Stewart, & Tingley, 2019). We estimated multiple topic models with varying values of the model parameter K to ascertain the optimal number of topics. Our evaluation criteria encompassed measures such as semantic coherence and exclusivity, with detailed test statistics reported in Appendix 2-B. Beyond quantitative metrics, we also considered the semantic interpretability of topics, assessing factors like clearness, relevance, and distinctiveness of model results with different K.

Meanings not only reside in individual topics but also emerge from the way in which they are organized (see also Lakoff, 2010). Therefore, after identifying the major topics, we focused on the relational structure of topic association in the second part of our analysis. This involves several analytical steps. First, we constructed a series of temporal topic networks based on topics' co-occurrence relationships in individuals' posts each year[6]. These yearly networks were binarized to focus only on the top 10% strongest associations within each year. Topics' degree centrality — defined as the number of nodes a given node is directly linked to in the network (Freeman, 1978) — was then calculated to identify central topics in online climate change discourse, considering higher degree centrality as indicative of common interests among many Weibo users. Second, based on the high probability keywords and representative posts of topics, we manually coded topics into three groups: Environmentalism-oriented, Development-oriented,

[6] We consider the topic that accounts for the largest proportion of the post text as the main topic of the given post.

and the Other themes. The environmentalism and the development groups were then compared on two dimensions. The first dimension assesses environmental and developmental topics' general visibility on Weibo, involving indicators such as the number of topics, the cumulative topic proportions, and the volume of posts. The second dimension focuses on the relational significance of environmental and developmental topics in public discourse. This involves quantifying and evaluating connectedness, including both topic-level connectedness (indicated by individual topics' yearly average degree centrality) and group-level connectedness (indicated by topic groups' yearly average internal density and external connection rate). Additional methodological details can be found in Appendix 2-A.

The last analytical component focuses on the temporal evolution of climate change topics on Weibo, which is particularly relevant given the dynamic landscape of China's environmental policies over the decade. We draw upon Snow and Benford's framing analysis taxonomy (1988) to discuss how environmental and developmental topics contribute to Chinese netizens' discussions in terms of the diagnosis (i.e., the way people perceive the nature and causes of climate change issues), prognosis (i.e., suggestions for solutions and actions to mitigate or adapt to climate change), and motivation (i.e., the rationale or justification for climate actions) of climate change. By comparing the temporal changes of corpus proportions on each of these three framing aspects, we discuss how the public visibility of the environmentalism and development orientations of climate change discourse ebb and flow on Weibo.

3.4. Results

After estimating multiple topic models with varying values of the model parameter *K*, we settled with the model with 56 topics, which strikes a balance between rigorous quantitative criteria and

the qualitative interpretability of resulting topics. The assignment of topic labels was carried out by the first author (a native Chinese speaker) based on high-probability words and representative posts where the corresponding topic constituted the largest proportion of the text body. Among the 56 topics identified in our final model (K = 56), 16 were found to be not directedly related to anthropogenic climate change and were consequently excluded from subsequent analysis. Figure 3-2 presents the 38 climate change topics, arranged in order of their total proportions in the corpus. The full list of high probability words can be found in Appendix 2-C, along with a representative post (in the original Chinese language) and a succinct summary for each of the relevant topics.

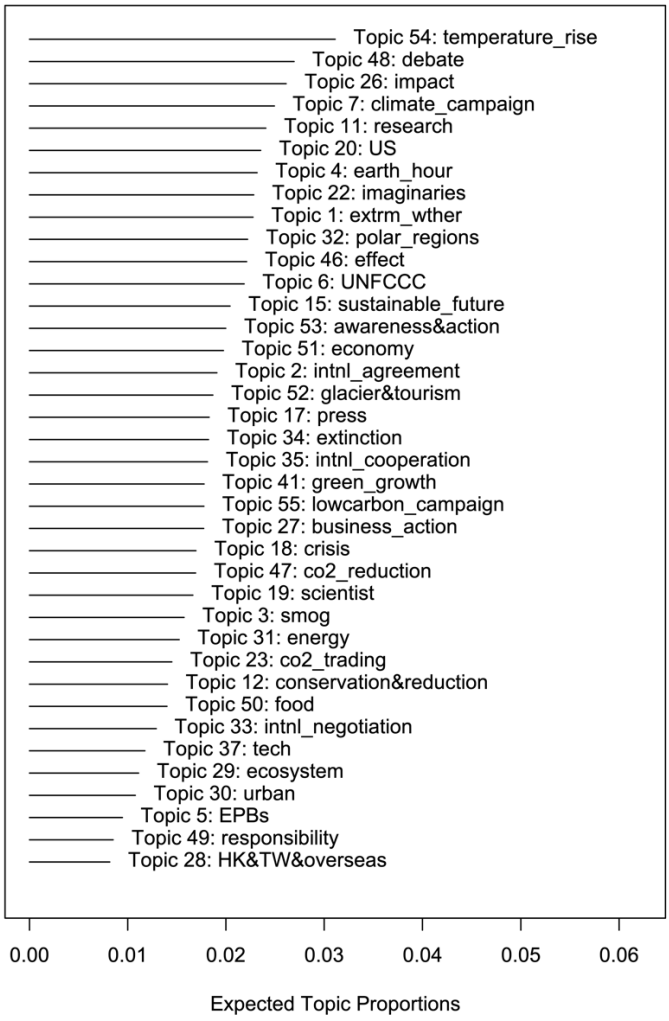


Figure 3-2 Major climate change topics in Weibo public discussion (2009–2019).
Note. Topics are ordered by expected topic proportions within the corpus.

Overall, the 38 climate change topics include a diverse array of subjects and issues related to climate change. A significant portion of public discussion centers on ecological and scientific evidence of climate change and its environmental impacts — examples include topic *temperature rise*, *debate*, and *impact*. Notably, a substantial part of the public discussion is driven by climate events, such as international COP climate conferences (e.g., *UNFCCC*), social media campaigns (e.g., *Earth Hour*), and temperature anomalies (e.g., *extreme weather*). Additionally, the online discourse places substantial emphasis on energy and carbon-related issues, with various topics addressing distinct facets. These include discussions on, for example, low-carbon economy (e.g., *economy* and *green growth*), energy policies and regulations (e.g., *energy* and *energy conservation & emission reduction*), market and financial instruments for emission reduction (e.g., CO_2 *reduction* and CO_2 *trading*), and efforts to enhance public awareness (e.g., *low-carbon campaign*).

We identified 16 environmentalism-oriented topics that focuses on ecological aspects of climate change (e.g., *temperature rise*, *extreme weather*, *impact*, *ecosystem*) and 17 development-themed topics that emphasize the economic, social, and political aspects of climate change in relation to national development (e.g., *low-carbon development*, *UNFCCC*, *international agreement*, *economy*, *energy*). Figure 3-3 illustrates the aggregated network[7] of co-occurrence relationships among topics, with colours indicating thematic groups.

[7] The aggregated network is a weighted static network, where edge weights represent the number of years two topics show a strong (top 10%) connection relationship.

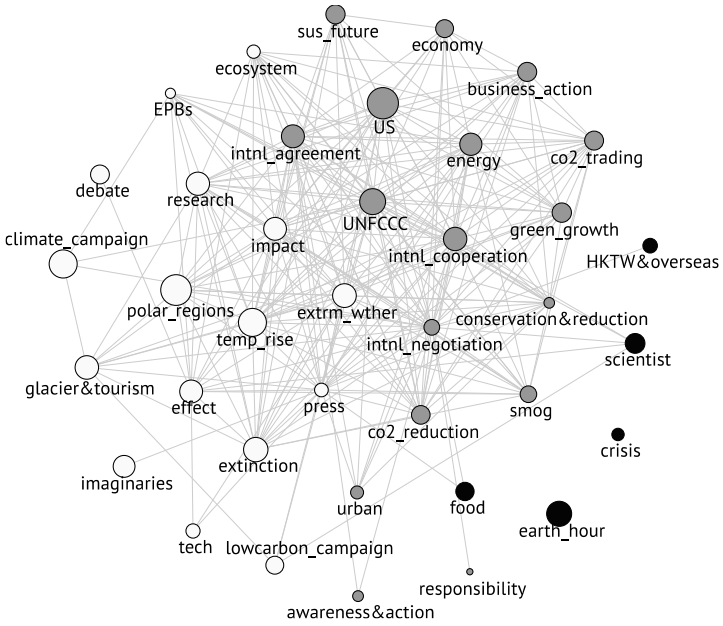


Figure 3-3 Aggregated network of topic associations, with node colour showing the thematic group.
Note. white: environmentalism, grey: development, black: other) and node size reflecting topic proportion within the corpus.

These two groups exhibit comparable visibility on Weibo, evidenced by their similar number of topics (16 and 17, respectively) and the proportions of posts dedicated to related discussions (47% and 41%, respectively). However, distinct patterns emerge when the temporal dimension is taken into consideration. As illustrated in Figure 3-4, both groups displayed nearly identical distributions in early years until the environmental topic group gained greater visibility in 2012. The subsequent years, spanning 2013 to 2017, witnessed a noteworthy surge of development topics, whose public visibility reached their pinnacle in 2015. Public attention on environmental topics has resurged in recent years, surpassing that on developmental topics since 2017.

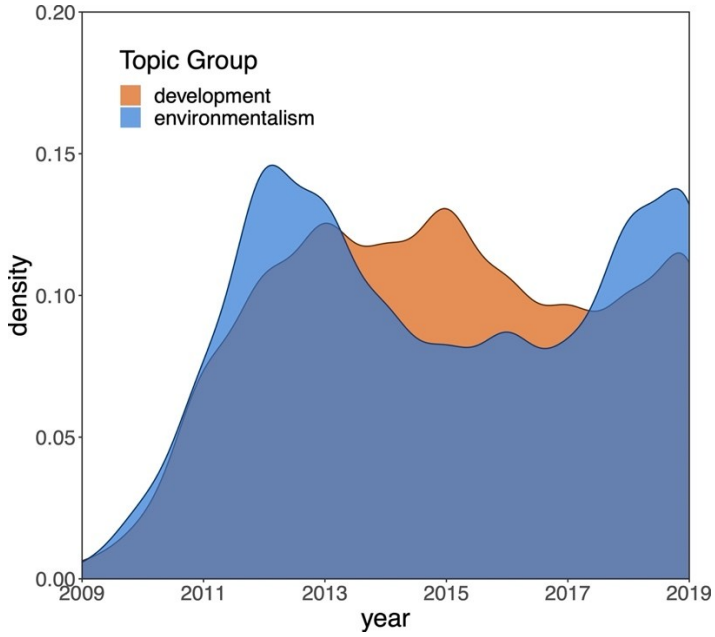


Figure 3-4 Kernel density estimates of the temporal distribution of Weibo posts in the environmental and the development topic groups.
Note. Bandwidth = 0.5.

While environmental topics comprise a slightly larger proportion of the Weibo climate change corpus, our network analysis reveals that development topics present a different kind of discursive prominence on Weibo. We find that development-related topics tend to have a higher level of network centrality and exhibit a more tightly connected relational structure in online climate change discussions. On the individual topic level, development topics generally maintain a larger number of strong connections with others over years (degree centrality μ= 10.07, σ= 7.08) in comparison to the environmentalism ones (degree centrality μ = 6.97, σ= 6.72). On the group level, the development group also demonstrates a significantly higher average internal density (μ= 0.34, σ= 0.03) than the environmental group (μ= 0.05, σ= 0.01) over years. These mean that Weibo users are more inclined to discuss multiple developmental-related issues simultaneously in their online expressions about climate change, indicating a more cohesive and consistent thematic focus within the development group in public discourse. The

environmentalism orientation of climate change discourse seems to be a less centripetal theme on Weibo by comparison. Although environmentalism-related topics tend to be larger by size, their bonds appear looser in individuals' online expressions. Furthermore, we find that the environmental topic group's internal connections tend to be even sparser than their external connection with developmental topics ($\mu = 0.28$, $\sigma = 0.04$). This seems to suggest a gap in Weibo users' understandings or ways of communication about the interdependence among different environmental impacts and the holistic nature of climate change's ecological influences on humanity.

Our last part of the analysis focuses on examining the temporal evolution of the public discourse in framing the diagnosis, prognosis, and motivation around climate change. First, we find that the diagnostic framing of climate change on Weibo involves many large environmental topics (e.g., *temperature rise*, *extreme weather*, *polar region*, *extinction*, and *imaginaries*), but only a few development topics (i.e., *economy* and *food*). This suggests that, in Weibo discussion, climate change's problem definition centers more on its ecological manifestations and consequences rather than its developmental representations. In terms of the temporal development of topic prevalence, we find the two orientations exhibit converse patterns on Weibo. exhibited a predominantly upward trend over time, with the exception of the years between 2014 and 2017, a time when the two developmental diagnostic topics garnered more public attention than in the rest of the timeframe.

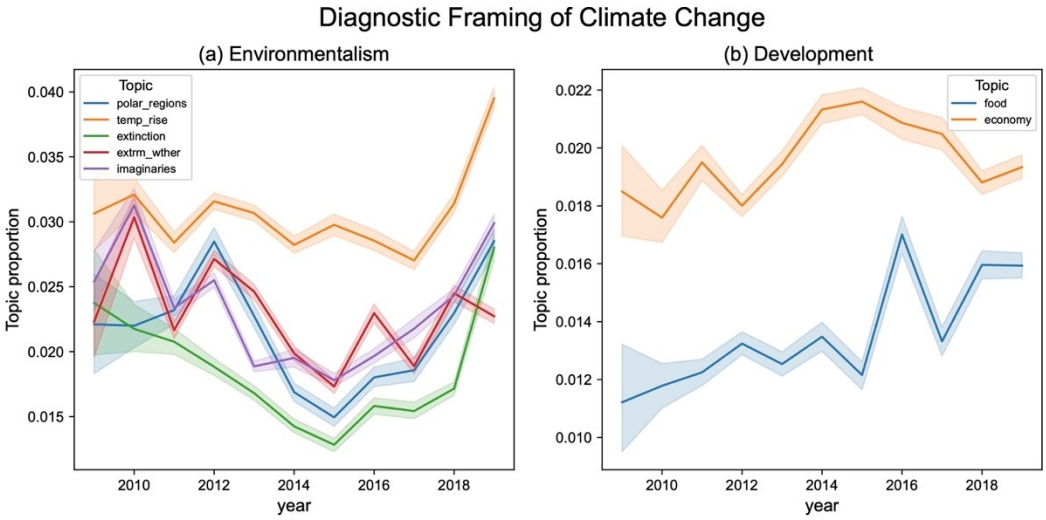


Figure 3-5 Evolution of topics related to diagnostic framing of climate change.

While the diagnosis of climate change revolves around ecological dimensions on Weibo, we find the prognosis of the issue is predominantly framed through development-related topics, particularly those about energy and carbon. Topics such as *energy*, *green growth*, *business action*, *CO_2 trading*, *CO_2 reduction*, *conservation & reduction program*, and *low-carbon campaign* underscore green development as the primary avenue for addressing climate change, with a notable emphasis on energy transition, economic transformation, and the reduction of CO_2 emissions through technological advancements and carbon market mechanisms. We find public visibility of these topics presented a consistent evolving pattern on Weibo. As illustrated in Figure 3-6a, most of the development prognostic topics experienced a notable surge from 2012 and peaked around 2014 and 2015, indicating a substantial increase of public attention on of the developmental orientation of climate change discourse on Weibo during this period. Within the environmentalism topic group, two distinct prognostic frames emerge. One emphasizes the importance of environmental science and technology (i.e., *research* and *tech*) in addressing climate change, which maintained a relatively stable level of visibility over time (Figure 3-6b).

Two environmental campaign topics — *low-carbon development campaign* and *climate campaign* — comprise the other environmentalism-oriented prognostic frame that emphasizes individuals' lifestyle change as a way to address climate change. Public attention on this green lifestyle prognosis frame has remained moderately high throughout the time, until experiencing a significant uptick in 2018 (Figure 3-6b).

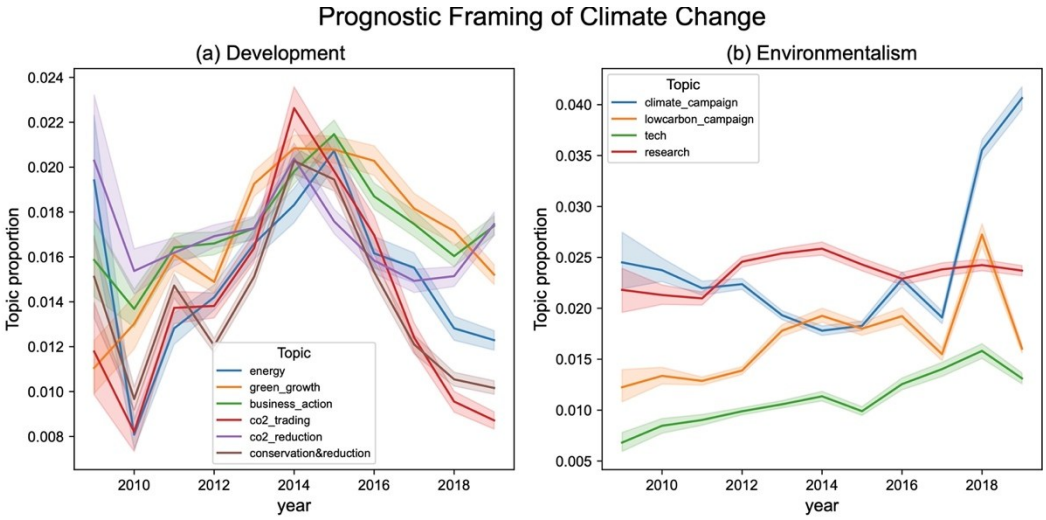


Figure 3-6 Evolution of topics related to prognostic framing of climate change.

Regarding motivational framing, we find that the demarcation between environmentalism and development themes is not evident. Instead, topics can be differentiated along a crisis–opportunity fault line. By portraying dire natural disasters and social situations, the two crisis-oriented topic i*mpact* and *crisis* may evoke fear and present a relatively passive motivation for responding to climate change. Conversely, the topics *sustainable future* and *responsibility* present a more optimistic motivation to address climate change as they highlight opportunities for a sustainable future and underscore globally shared responsibility. Notably, we find that these contrasting motivations do not engender a competitive dynamic for public attention; rather, topic prevalence for both frames exhibits similar evolving trajectories on Weibo as shown in Figure 3-

7. This juxtaposition between reactive and proactive motivational frames differs from our observations in diagnostic and prognostic topics, where environmentalism and developmental orientations appear to be two distinct interpretive frameworks competing for public attention in framing climate change issues on Weibo.

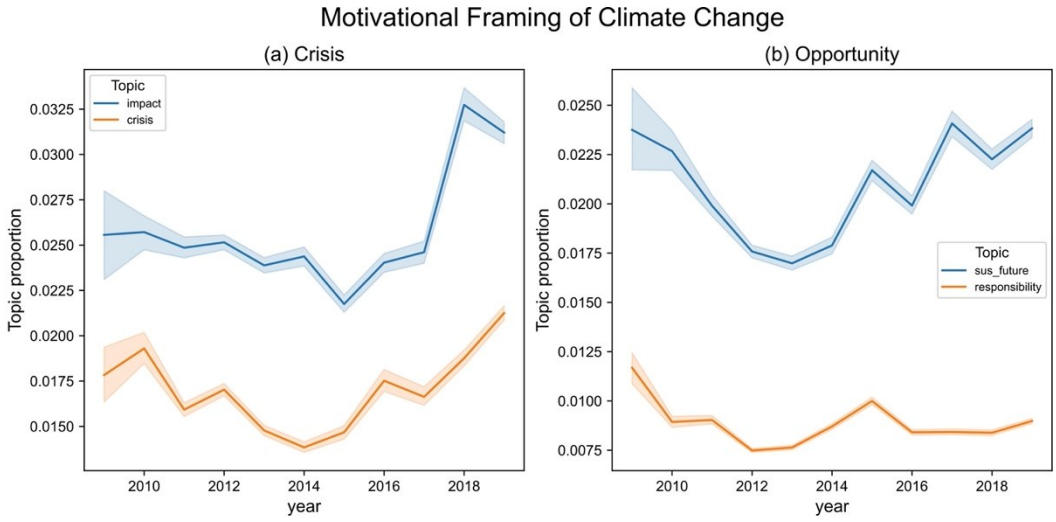


Figure 3-7 Evolution of topics related to motivational framing of climate change.

3.5. Discussion

Overall, this study finds that online climate change discussions among Chinese public on Weibo align closely with the developmental environmentalism discourse. The major topics and the network structure of their associations underscore the interconnection between environmental and developmental goals, the convergence of climate action and economic sustainability, as well as emerging opportunities for national development through avenues such as green technology, renewable energy, climate financing, green infrastructure construction, and proactive engagement in international climate politics.

Our topic model and topic network analysis have brought to light two key observations. First, there exist significant and close interconnections between environmentalism and

developmental topics in Weibo users' climate discussion, highlighting a composite narrative between the environmental and development goals in relation to climate change. This aligns with the developmental environmentalism discourse, where the pursuit of economic growth is increasingly viewed through the lens of environmental sustainability and vice versa. This finding indicates that a non-dichotomous understanding regarding the interplay between environmental concerns and developmental goals in the context of climate change is prevailing among the Chinese public on Weibo.

Second, we find that while environmental topics are larger by size, developmental topics exhibit a higher level of network centrality in the online discourse of climate change on Weibo. The expansive scope of public discussions on diverse environmental issues, encompassing air quality, water pollution, biodiversity, and other environmental concerns spanning global to individual levels, underscores the public's awareness of the far-reaching environmental impacts of climate change. On the other hand, development-related topics hold higher prominence in the online public discourse on the network relational dimension. Their heightened relational centrality implies that, for many individuals, development serves as a pivotal concept — a hub through which various facets of climate change are interpreted and communicated. Moreover, the persistence of development topics' high centrality across different time periods underscores the enduring prioritization of developmental issues in the public discourse of climate change on Weibo. Reflecting the nation's historical and ongoing emphasis on economic growth, the public may perceive climate policies and their effectiveness in relation to their alignment with, and more significantly, support for developmental goals. This characteristic may be viewed as an extension of the developmental state model (C. Johnson, 1982; Woo-Cumings, 2019) in public

discourse, wherein economic objectives not only take precedence but also serve as the lens through which other public issues are evaluated.

Furthermore, the trajectory of major climate change topics seems to reflect an agenda-setting influence wielded by China's official and policy narratives over public discourse. This is first indicated by the observation that public discussions tend to focus more on the macro-level economic opportunities for national development (e.g., the strategic importance of advancing green technologies and renewable energy sectors) than on micro-level development aimed at enhancing individuals' everyday life quality (e.g., cheaper energy bills and clean air). This dominance of grand narratives implies a noteworthy permeation of the official climate policy discourse into public conversations and its power in shaping individuals' imaginaries of what constitute a more sustainable future and the pathways toward it.

The agenda-setting influence becomes more evident when examining the evolution of topic prevalence on Weibo. Evolving trajectories of public online discourse closely align with changes in the country's official eco-political narratives over time. Indicated by the prevalence and centrality of contentious topics like *international negotiation*, public skepticism and cynicism toward international climate politics was evident on Weibo from 2009 to 2012. This may reflect China's initial defensive posture in international climate negotiations, which was often described by the country's official media as arenas of power struggle with Western countries (see also J. C.-E. Liu, 2015). A pivotal turning point occurred in 2012, with public attention shifting towards more collaboration-oriented themes such as *international agreements* and *international cooperation*.

Between 2013 and 2015, Weibo discussions notably gravitated towards the developmental environmentalism discourse. This period coincides with the introduction and elevation of the

Belt and Road Initiative (BRI) in China's political agenda. Aligned with BRI's ambitious infrastructure development and investment goals, a substantial body of public conversation emerged to discuss energy development, carbon marketization, climate financing, and low-carbon development issues that frame climate action in the context of green growth and as a crucial synergistic strategy contributing not only to global climate environments but also to China's domestic development. The pinnacle of visibility for this development-oriented frame was reached in 2015 — the year of COP21 Paris Summit, during which China committed to ambitious goals of carbon intensity reductions and emissions peaking by 2030. The subsequent phase, spanning from 2016 to 2019, witnessed a resurgence of public attention on environmental topics on Weibo. This is China's 13th Five-Year-Plan (13th FYP) (2016–2020) period, which was hailed as the "greenest Five-Year-Plan ever" (Xinhua News, 2020). This is also a time when *Ecological Civilization* began to overtake the terminology of sustainable development in China's social and policy dialogues (Goron, 2018) and became institutionalized in the country as a vision for a new social-ecological future. The heightened environmentalism–development linkage we observed on Weibo during this period is consistent with the official narratives' emphasis on the notion that environmental well-being is an essential component of national development — as encapsulated in Xi's "Five-in-One strategic deployment" *(五位一体总体布局)* in 2017 which depicts an integrated vision for a social-ecological future of modernization that is characterized by moderate economic growth, socialist democracy, cultural prosperity, social harmony, and ecological civilization construction.

Examining the evolution of topic prevalence on Weibo reveals a shift in the online discourse from taking a defensive stance, where climate policy is presented as a burden, to acknowledging climate mitigation as an integral aspect of China's modernization development.

This trajectory suggests an increasing public awareness of the interdependence between development and environment, aligning with the tenets of the developmental environmentalism discourse. Recognizing the unfolding process of developmental environmentalism enriches our understanding of China's pro-environmental initiatives and proactive measures on climate change in recent years.

A limitation of our study lies in the lack of differentiation of the identity of Weibo users examined in our data. Weibo, despite being a social media platform, hosts a diverse array of account types, including governmental originations, official media, and other entities that may represent elite voices rather than that of the general public. Consequently, caution should be exercised in interpreting the findings of this study, and they should not be unequivocally generalized as representative of so-called public opinion from Chinese citizens. Acknowledging this limitation, we advocate for future research to adopt a more nuanced research design by differentiating and comparing various types of Weibo users engaged in climate change discussions. Such an approach would contribute to a more comprehensive understanding of how different social groups perceive, shape, and reshape the evolving discourse on climate change within China's online sphere.

3.6. Conclusion

This study offers insights into how the Chinese public engages with online discourse on climate change on the country's top social media platform Weibo. Through analysing the major topics, the network structure of their association, and their evolution trajectories, we find that development-oriented topics present high prominence within the climate discourse on Weibo, which aligns closely with the central tenets of developmental environmentalism. This signifies

the public's awareness of interdependencies between developmental and environmental goals, and of the idea that restructuring the economy toward a more climate-sustainable model is paramount in the context of climate change.

The prominence of developmental environmentalism in online discussions reflects an optimistic perspective among Weibo users, from which climate efforts are viewed as an opportunity to leapfrog to cleaner energy and advanced technologies. This optimism echoes China's official Ecological Civilization narratives about incorporating environmental considerations into the fabric of China's socio-political development. As an eco-political framework, Ecological Civilization has sparked discussions regarding its implications outside China and its potential (or lack thereof) to serve as an alternative pathway to green prosperity that transcends beyond Global North-centred experience. On one hand, we hold an optimistic view of the value of Ecological Civilization and the underlying developmental environmentalism discourse in expanding the global "varieties of environmentalism" (Guha & Alier, 2013). A perspective that emphasizes an organic fusion of developmental goals and environmentalism is particularly important for developing countries where climate imperatives often contend with, or are overshadowed by, local needs for socio-economic prosperity. The making and implementation of climate policies require a delicate balance of competing priorities (Harrison & Kostka, 2014). Therefore, a discourse aligning the multiple facets of climate change is promising for garnering support from diverse interest groups. However, a development-centred approach remains entrenched in the hegemonic "growth paradigm" (Jackson, 2016; Kallis et al., 2018), thus caution is warranted regarding its limitations in addressing the fundamental conflict between the imperative for climate mitigation and the challenge of decoupling GDP growth from resource consumption and carbon emissions. Further research is essential to explore the extent to which

the development orientation of climate change discourse goes beyond rebranding the pursuit of materialism-based GDP growth. Finally, given China's increasing influence on forging the climate mitigation and adaptation path for the Global South (Qi & Dauvergne, 2022), the developmental environmentalist approach to climate discourse is likely to find resonance beyond China, particularly through the avenue of the Belt and Road Initiative. However, its "exportability" and long-term implications remain unanswered questions that warrant further examination.

4. Chapter 4 Mutual Influences Between Climate Change Communication and Expressive Participation on Weibo: A Longitudinal Network–Behaviour Co-evolution Analysis

1.3 Abstract

Drawing on Reinforcing Spirals Model (RSM) theory and longitudinal network analysis methods, we analyse the co-evolution of climate change communication network and online expressive participation around climate policy issues on China's top social media platform Weibo (2019–2021). We find a mutual influence between actors' engagement in communication relationships and their participatory behaviours over time. However, this dynamic does not operate at the individual level. Active/popular actors in the communication network do not necessarily become more participatory later, nor does higher participation significantly lead to greater activity/popularity in the subsequent time point. Instead, this dynamic is characterized by concurrent homogeneity-based network selection and network influence processes. Model results show that actors with similar participation levels are more likely to form future communication ties and actors with existing communication ties are more likely to converge in participation levels over time. This indicates a homogeneity-based reciprocal influence between network connections and individual engagement. We also find that endogenous network structural factors play a significant role in shaping people's engagement with climate change communication. These findings underscore the importance of the social relational dimension in the dynamic interplay between communication and online expressive participation, contributing to a more nuanced understanding of the RSM theory.

Keyword: Reinforcing Spirals model, public participation, climate change communication, social media, longitudinal network analysis, Stochastic Actor Oriented Models

4.1. Introduction

A rich body of research has studied the implications of social media on citizens' engagement in public and political spheres. Political communication research has generally found a positive association between using social media for informational, expressive and social purposes and heightened citizen engagement in public/political affairs (Boulianne, 2015b; Skoric, Zhu, Goh, et al., 2016). However, empirical evidence for this positive link seems to be less consistent when factoring in temporality. In a meta-analysis, Boulianne (2015b) found that, although over 80% of the coefficients are significant and positive in cross-sectional studies, studies using panel data report less support for this optimistic view of social media engagement. This inconsistency raises a critical question about the directionality of the effect. The same positive association could result from either a communication *influence* process (where informational or interactive use of social media drives civic engagement) or a communication *selection* process (in which participatory individuals proactively craft their social media environment for public/political purposes). It could also emerge from both processes occurring simultaneously. Lumping these processes together may be theoretically problematic and practically misleading, particularly when the positive association is interpreted as implying an optimistic facilitating influence of social media.

To develop a more comprehensive understanding of social media's role in public/political life, it is important to differentiate the influence and selection processes and disentangle their temporal sequences in the dynamic interplay between social media use and public participation. Drawing on the Reinforcing Spirals Model theory (RSM) (Slater, 2007, 2015) and using Stochastic Actor-Oriented Models (SAOMs) (Snijders, Bunt, & Steglich, 2010), this study analyses the co-evolution between communication relationships and online expressive

participation behaviours to study whether and how individuals' digital interactions and their online participation behaviours influences each other over time.

We examine the empirical case of climate change communication and online expressive participation on Weibo, China's top microblogging platform. With a reputation for public influence, Weibo is an important venue for the Chinese public to seek alternative information, express political grievances, and mobilize non-confrontational collective actions (E. L. Han, 2018; R. Huang & Sun, 2014; Rauchfleisch & Schäfer, 2015). Its public orientation makes it an intriguing case for studying the new extra-institutional, decentralized, and networked mode of public participation — a new way of being political, as noted by scholars such as Bennett (2012) and Theocharis (2015) — in a country where institutional participation channels are largely constrained.

We focus on Weibo users' online expressive participation — a form of digitally networked participation that entails publicly expressing one's political views on public/political affairs online (Rojas & Puig-i-Abril, 2009) — in public debates over the country's climate policies. Since Verba and Nie's landmark work in 1987, the meaning of public participation has undergone significant changes, expanding from its initial focus on "influencing the selection of governmental personnel and/or the actions they take" (Verba & Nie, 1987, p. 2) to encompass a range of individualized, expressive, lifestyle-focused, and "DIY" forms of citizen engagement (Bennett, 2008; Bennett & Segerberg, 2012). Beck's concept of "sub-politics" encapsulates this disenchantment with conventional politics, wherein political decisions, actions, and transformations are increasingly being taken outside of traditional political institutions and hinge on mediated communicative events to mobilize public pressure (Beck, 1997, pp. 52–54). These new participatory actions might appear to be transient, tangential, or issue specific, especially

when conducted in online settings, yet their implications are far from trivial. Everyday communicative actions make public/political agendas more accessible and relatable to individuals. Even though they may lack the formal structure and rule-guided process of conventional deliberation, the continuous exchange of ideas, perspectives, and experiences play a crucial role in forming the bedrock of "everyday politics" and contributing to a potentially more informed, engaged, and active citizenry (Benkler, 2006; Dahlgren, 2005; Neblo, 2015; Shirky, 2011).

Drawing on this body of the literature, we conceptualize online political expression as a form of public participation. This form of everyday political participation is valuable in China's unique socio-political context, where formal institutionalized citizen participation avenues are still underdeveloped. So-called online "public opinion incidents" or "mass incidents" bring social grievance under the spotlight and transform individual incidents into collective affairs (deLisle et al., 2016; R. Huang & Sun, 2014). Netizens' influence to shape the political agenda becomes unprecedently intensified with the advent of microblogging platform Weibo in 2009. This has given rise to a cultural practice known as the "surrounding gaze" (*围观*), wherein collective attention and discussion are harnessed online to exert influence on political processes and challenge official narratives over public/political affairs in China (Teng & Mosher, 2020; Zuo & Tong, 2015).

However, considerable restrictions on political communication characterize China's digital landscape. Research on China's digital media have revealed a complex system of censorship and surveillance that meticulously controls social media discourse, controlling content with the potential to mobilize collective actions (Chin & Lin, 2022; King, Pan, & Roberts, 2013). However, the political communication environment shows a different face when it comes to

certain topics such as environmental issues, food safety, and civic livelihood issues. These more negotiable terrains constitute what Rauchfleisch & Schäfer (2015) call a "thematic public sphere on Weibo" where open debates and criticisms of political authorities concerning public policies and impacts are tolerated or even encouraged. In particular, the online green public sphere concerning environmental issues stands out as one of the most vibrant and influential areas, demonstrating a notable level of openness, sustained engagement, and significant participant involvement. (Rauchfleisch & Schäfer, 2015; G. Yang & Calhoun, 2007). In this study, we focus on this online green public sphere as a specific case of political communication.

While we believe that studying climate communication can shed light on political communication within China's socio-political context, we also acknowledge that dynamics in climate communication are not always the same with that of other conventional political discourses. Political, cultural, and ideological factors that lead to varying levels of public understanding or various forms of climate skepticism make effective climate change communication more challenging than in other political issue areas where there may be more consensus or neutrality. Moreover, climate change is a "boundary-spanning" policy issue that crosscut a wide array of societal sectors and builds on the linkages between multiple policy subsystems (Jochim & May, 2010; Jones & Jenkins-Smith, 2009). Communicating climate change, therefore, necessitates a more nuanced approach that encompasses the diverse and interconnected facets of climate change.

A rich body of research has underscored the critical importance of climate communication in relation to public participation in climate change discourse and politics. Over the past two decades, social media platforms stand out as important spaces where people cultivate, shape, and reshape their perceptions, opinions, and identity concerning climate change discourse an politics

(for reviews on climate communication on social media, see Moser, 2016; Pearce et al., 2019). Studying climate communication on Weibo, thus, offers a lens through which to examine the dynamic interplay between political communication and public participation in China's unique socio-political context.

Using a three-year (2019–2021) panel dataset of Weibo users' digital traces in climate change communication and participation, we examine whether and how communication network ties and individuals' participation behaviours mutually influence each other over time. Results of our network–behaviour co-evolution model lend empirical support to the RSM from a network analysis perspective and highlight the importance of social relations in driving the mutual influences between communication and participation. We find that the communication–participation reinforcement is characterised by reciprocal yet asymmetric effects of both network selection and network influence, leading towards homogeneous participation behaviours within one's online social network. These findings add important nuance to our understanding of communication–participation reinforcement in the new networked media environment, with theoretical implications beyond Weibo as a specific social media platform.

4.2. Literature Review

4.2.1. A Social Network Approach to the Reinforcing Spirals Model (RSM)

The Reinforcing Spirals Model (RSM) (Slater, 2007, 2015) posits that consuming specific media content or engaging in discussions with individuals who hold certain opinions may lead individuals to develop corresponding viewpoints, which, in turn, can further lead to attitude- or behaviour-congruent content consumption and interpersonal discussions (Slater, 2007). This model emphasizes the mutual influences between political communication and its

attitudinal/behavioural outcomes. In this cycle, exposure to mediated communication or engagement in interpersonal communication shapes an individual's social identity — as manifested in more transient political attitudes and behaviours; simultaneously, the desire to maintain one's social identity leads individuals to seek out content or discussions that align with their views (Slater, 2007, pp. 281, 291). Seen in this light, communication *influence* and *selection* are not static or mutually exclusive processes, but reciprocal and intertwined components of a larger cumulative cycle that influences how individuals construct and maintain their social identities.

The RSM's core assertation on the mutual reinforcement between communication and its political outcomes has been tested in various contexts. Political attitude-based reinforcement is a well-researched theme in this body of the literature. Many studies have demonstrated an over-time reinforcement between partisan attitude/identification and opinion-congruent communication, including both mass mediated and interpersonal communication (e.g., Binder, Dalrymple, Brossard, & Scheufele, 2009; Hutchens, Hmielowski, & Beam, 2019). The reinforcement of interests or behaviours related to political participation is another important thread of empirical research — although no study, to our knowledge, has examined this topic in the specific case of environmental politics up to this point. Beyond general support for the RSM, these participation-focused studies reveal several nuanced findings about the positive feedback loop between communication and participation. For instance, Feezell (2016) compared opinion-congruent political information with cross-cutting and non-political information and found that perceived exposure to opinion-consistent political information predicts higher levels of online participation. Moreover, some studies pointed to the asymmetric nature of the communication–participation reinforcement. Most of these studies suggest that effect from participation to

communication is stronger and more stable than the other way around (Slater, Shehata, & Strömbäck, 2020). This relative strength of communication selection effect has been identified in various contexts, including adolescents' news use and political engagement (Kruikemeier & Shehata, 2017), TV news consumption and political interest (Strömbäck & Shehata, 2019), and incidental news exposure in social media and political participation (Lee & Xenos, 2022).

While empirical evidence for mutual influence as per the RSM is increasing, we notice that previous studies have largely been grounded in what Schumpeter terms "sociological individualism," which views social phenomena as the outcomes of autonomous individuals' decisions and actions without invoking broader interpersonal or collective factors (1954, p. 888). What has been generally overlooked in existing RSM research is the social network structures that contextualize individuals' actions in communication and participation and people's interdependency in these activities. Many scholars have highlighted the power of online social relations as an important catalyst for political participation and persuasion (e.g., Bode, 2012; Bond et al., 2012). Neither communication influence nor selection occurs in a social vacuum. Instead, individuals' actions in both processes are contextualized by the social networks in which they are embedded. Analysing the effect of social networks is also important for methodological reasons. Previous empirical studies on the RSM have mostly measured communication activities as an individual attribute and assessed through individual covariates, such as the frequency of media and the type of media consumption. Even in social media-based or interpersonal communication research, prior studies mostly conceptualize people as independent actors and measure their communication activities as individual characteristics (e.g., the status of incidental news exposure and the level of involvement in interpersonal discussion). However, social media-based communication is inherently interactive. Applying classic statistic methods that rely on the

sample independence assumption in this context could lead to incomplete theoretical conceptualization and flawed methodological operationalization.

Network analysis provides a powerful analytical and methodological framework to analyse the relational structure that contextualizes people's communication activities. The network science literature has discussed the dynamic interplay between network structures and individual characteristics. This includes studies focusing on the network *influence* process, where actors are influenced by others in their social networks and thus change individual characteristics (e.g., Friedkin, 1998) and those on network *selection* processes, where actors actively seek out others to form network relationships based on individual characteristics (e.g., McPherson, Smith-Lovin, & Cook, 2001).

Drawing on network analysis literature, this study investigates the mutual influence between communication and participation through examining co-evolution of digital communication network ties and individuals' online expressive participatory behaviours. Our analysis aims to study if network influence and selection exhibit a reciprocal relationship over time, thereby exploring the RSM theory from a network perspective.

4.2.2. Climate Change Communication Network and Online Expressive Participation

The interactive mode of social media communication differs from the vertically structured and monological "mediated quasi-interaction" (Thompson, 1995) of legacy media, where the production and reception of symbolic forms are separated. This technological architecture allows for, at least theoretically, structurally decentralized information creation and diffusion that is carried through users' online interaction ties. The consolidation between information consumption and social interaction is particularly evident on micro-blogging platforms, where

ties in online social networks serve as the conduit to structure both information dissemination and interpersonal discussion activities. Seen in this light, examining the structure of users' ties in communication networks allows us to for both informational and interactional use of social media.

In this study, we construct user networks based on their interactive relationships in Weibo climate communication and use SOAM to examine the temporal changes of tie presence/absence in these networks. We also distinguish the direction of relationships so that the number of in-coming ties indicates popularity whereas the number of out-going ties indicates activity in communication. We propose three main sets of hypotheses to test the effect between network relations and individual behaviours in both directions, as well as network structural effects that contextualizes the mutual influence.

We first posit a general over-time association between the level of communication engagement and that of participation. Studies have shown that a larger (i.e., with more actors) and denser (i.e., with a closely knit structure where actor are more directly interconnected) political discussion network is positively correlated with receiving more political information, developing greater political knowledge and efficacy, and thus contributing to the increase of political participation or civic engagement (e.g., Eveland, Hutchens, & Morey, 2013; H. Song & Eveland, 2015). Specific to climate communication, Arlt et al. (2018) find that exposure to climate change information via social media and engaging in interpersonal discussions about COP21 significantly promote people's online participation in climate discourse. On the other hand, Taddicken and Reif's (2016) study shows that participating experts who have high levels of interests and procedural knowledge in climate change topics are more active in generating, disseminating, and discussing climate-related content on social media. These studies suggest

evidence for each direction of the mutual influence between communication and participation. Following the RSM's proposition, we integrate these insights by proposing a bidirectional effect: a higher level of engagement in climate change communication leads to a higher participation level over time and that increased participation in turn motivates individuals to engage in more communication activities over time. Therefore, with the directions of the user tie distinguished, we first hypothesize that:

Hypothesis 1: a higher level of activity (***H1a***) and popularity (***H1b***) in climate change communication network predicts a higher level of participation in the subsequent period.

Hypothesis 2: a higher level of participation in debating climate policies predicts a higher level of activity (***H2a***) and popularity (***H2b***) in climate change communication in the subsequent period.

We further hypothesize that network homogeneity is an important factor in the co-evolution of communication relationships and individual participation behaviours. This is grounded on the extensive research on echo chambers, filter bubbles, and polarization in the social media context. Since the early days of digital communication technologies, scholars have expressed concerns over the ability of digital media platforms to enhance user selection, leading to a closed media environment where beliefs are amplified or reinforced by homogeneous information and interactions, and insulated from rebuttal (Jamieson & Cappella, 2008; Pariser, 2011; Sunstein, 2017). The underlying principle is that, within these close media systems (i.e., echo chambers), people's pre-existing opinions are reflected back at them through clustered interactions with like-minded people and content tailored to their preferences (i.e., filter bubbles). This may result in minimal exposure to alternative perspectives or opinions, leading to

information silos that solidify existing beliefs and hinder the development of mutual understanding among different social groups (i.e., polarization).

However, recent empirical research presents a mixed view on the actual prevalence of echo chambers. While some studies have found supporting evidence, particularly on social media platforms where algorithms can create feedback loops of similar content and clustered user interactions (e.g., Bakshy, Messing, & Adamic, 2015; Barberá, Jost, Nagler, Tucker, & Bonneau, 2015; Kaiser & Rauchfleisch, 2020), other research indicates that the phenomenon might not be as pervasive as previously thought. Investigations into user online behaviors have shown that individuals often consume a more diverse range of information than the echo chamber hypothesis suggests (e.g., Dubois & Blank, 2018; Fletcher, Robertson, & Nielsen, 2021; Masip, Suau, & Ruiz-Caballero, 2020). Furthermore, the extent to which information/interactions in online echo chambers translate into real-world beliefs and actions remains understudied, especially when we consider the variety of media outlets and other social factors individuals engage beyond the digital sphere (see also Ross Arguedas, Robertson, Fletcher, & Nielsen, 2022).

Most of the empirical studies approach echo chambers primarily through the lens of partisan or ideological beliefs. Although many of their insights could also help us investigating public engagement and political participation, specific research on the potential impact of past participation behaviors on the formation of like-minded clusters remain scarce. In our study, we aim to bridge this gap by integrating discussions from two distinct but related fields: the analysis of echo chambers within political communication and the examination of homogeneity based on social network literature. By doing so, we seek to explore whether and how homogeneity plays a role in communication–participation reinforcement.

On one hand, homophily — the tendency for people to interact with others who share similar characteristics (McPherson et al., 2001) — is an important driving force for network *selection*. Political communication research has demonstrated that individuals tend to form opinion-affirming clusters in political discussions through either seeking like-minded others or avoiding those with dissimilar views (e.g., Huckfeldt & Sprague, 1995; Mutz, 2006). In social media environments, relational connection-based information transmission structures, combined with algorithm-driven exposure, allow users to easily build a highly personalized media environment in accordance with their pre-existing views and political leanings (Thorson & Wells, 2016; Winter, Metzger, & Flanagin, 2016). The social orientation of social media further strengthens this selection tendency and its impact. Because intimacy promotes trust, one's online social groups — often made up of demographically similar peers or likeminded others — become a natural magnifier for opinions, including confirmation biases (Westerwick, Johnson, & Knobloch-Westerwick, 2017). Research has also identified a significant selection effect in the specific context of climate change communication on various social media platforms. For instance, studies find Twitter users are segregated into polarised sceptic and activist groups and most online interactions only occur within their like-minded community, raising the risk of forming echo chambers in climate communication (Jang & Hart, 2015; Williams, McMurray, Kurz, & Lambert, 2015). However, this body of research has mostly focused on climate belief-based homophily along the activist—scepticism fault line in the Anglosphere where individuals' beliefs and perceptions of climate change become increasingly associated with their political identities (see also Chinn, Hart, & Soroka, 2020; McCright & Dunlap, 2011). In societies where partisanship-induced climate denialism is less of concern, the mechanism of network selection remains understudied. Yang et al. (2021) found that the Chinese public perceptions of climate

change are less polarized and climate denialism is not prominent in the perception spectrum. As such, instead of testing climate belief-based selection effects, we expect people's past engagement in climate policy debates to be a more relevant factor in the formation of homophilic communities in climate communication networks on Weibo and propose:

***Hypothesis* 3**: actors with similar participation levels are more likely to form a network tie at a subsequent time point.

On the other hand, homogeneity may be a consequence of network *influence*. Centola (2010) found that behavior adoption is much more likely if people are exposed to many others who have adopted the behaviour. This effect may be attributed to an informational reason. Encountering and exchanging information on social media can influence users to adopt behaviours similar with those in their online social networks. Network influence may also work through solidifying one's social identity. Specifically regarding climate change, research has identified the environmentalist social identity and related participation norm as significant predictors for engaging in climate actions (e.g., Bamberg, Rees, & Seebauer, 2015). Social ties in climate communication networks can not only serve as the conduit for accessing relevant climate policy information, but also help to build a sense of connection essential for forging social identities. On these bases, these social ties can lead actors to adopt similar participation practices as those with whom they interact. As such, we hypothesize that:

***Hypothesis* 4**: actors with a communication network tie are more likely to adopt similar participation levels at a subsequent time point.

While homogeneity in online networks could be the results of either selection or influence processes, or some combination thereof, previous research has mostly tackled the two sides of the story separately, examining selection or influence independently. So far, no study (to the best

of our knowledge) has investigated the potential cyclic interaction between network selection and network influence in the context of online public participation as argued by the RSM theory. This study intends to provide such an account, through synthesizing the two aspects and testing them jointly in our network-behaviour coevolution model.

Furthermore, network analysis research emphasizes network structures' self-organization tendencies, which have also been discussed in many political communication studies (e.g., Lazer, Rubineau, Chetkovich, Katz, & Neblo, 2010; H. Song, 2015; H. Song & Eveland, 2015). In this study, we include three groups of network effects in our model to test the effect of endogenous structural factors in driving tie formation in the Weibo climate change communication network.

The first group of network effects addresses basic relational propensities in social interaction: reciprocity and transitivity. Reciprocity refers to the mutuality of relations in social networks (Wasserman & Faust, 1994). Numerous studies have consistently found that actors in online communication networks tend to establish balanced relationships as they exchange information and interact with others (e.g., Choi, Yang, & Chen, 2018), including the specific case of climate communication on Weibo (Author, 2021). Transitivity describes a situation where actors are more likely to create a direct tie if they are both connected to a third one (Wasserman & Faust, 1994). Transitivity is found to be a significant factor in the evolution of various offline networks (e.g., Contractor, Whitbred, Fonti, & Steglich, 2012) but its impact on online discussion networks is unclear, with studies showing mixed results (e.g., H. Song, Cho, & Benefield, 2020; Y. Xu, Sun, Hagen, Patel, & Falling, 2021). In this study, we include reciprocity and transitivity in the model to test whether actors in the Weibo climate change communication network would reciprocate online relationships with those who have previously interacted with

them and whether they would form direct relationships with those who have previously interacted with their discussion partners.

Second, we anticipate that actors who have established popularity early in the communication network to have a cumulative advantage in attracting more connections over time — the tendency known as preferential attachment (Barabási & Albert, 1999). The long-tail shaped power-law distribution of connections in social networks is particularly prominent in online environments. Early research has revealed that most online attention is directed toward a small group of "super-nodes" on the Internet while the majority receive only a few, if any, connections (e.g., Himelboim, 2011). In social media, super-nodes are likely to be more visible to the public owning to heuristic cues of popularity on digital platforms such as the numbers of views, comments, and likes (H. Song et al., 2020). As such, we control for the higher likelihood of popular actors (i.e., actors with higher in-degree) in receiving more in-coming ties over time.

The final group of network effects concerns the effect of network connectivity on actor activity in communication over time. Sohn and Choi (2022) found that well-connected users are likely to remain as active communicators, whereas those with fewer social ties are likely to become relatively inactive "lurkers" in the long run. Therefore, we control for the tendency for active actors to become more active over time. Moreover, Wang and Shi (2018) observed that many Weibo users exhibit status consciousness when choosing who to follow, and that higher-status users seldom reciprocate attention back to their followers. As such, we control for the tendency for popular actors to initiate less out-going ties with others over time.

Lastly, we control for actors' digital prestige and issue-specific knowledge when modelling network dynamics, and control for actors' general interest in climate change discourse on Weibo when modelling behaviour dynamics.

In addition to network structural forces, some exogenous factors are also important predictors for people's engagement in social media-based communication networks. First, digital prestige is known to affect individuals' decision on choosing whom to follow or retweet in social media (e.g., Hoang & Mothe, 2018). Higher digital prestige often leads to perceptions of higher credibility, visibility, and influence, all of which contribute to popularity in online social networks. As a widely used indicator for digital prestige in social media research, the number of followers has been identified as a strong predictor of user attention and message circulation in social media (e.g., Bakshy, Hofman, Mason, & Watts, 2011). Moreover, one's offline social identity can also be translated into digital prestige. As such, Weibo's official identity verification system serves as a source of online prestige because a verified identity increases one's credibility and trustworthiness in online space. Studies have shown that users with verified identities are more likely to be followed or reposted on Weibo (R. Huang & Sun, 2014; Y. Song, Dai, & Wang, 2016). Therefore, we use the number of followers and identity verification status as the measures for actors' digital prestige on Weibo and expect that actors with a larger follower size and with verified identities are more likely to attract in-coming ties over time.

Follower size is a three-level ordinal variable that indicates the size of one's followers within all accounts in the full sampling roster. There are three categories: "small" (coded as 1), "medium" (2), and "large" (3). Out of the 153 study actors, 35 (23%) have a small number of followers, 59 (39%) have a medium number of followers, and 58 (38%) have a large number of followers. There is one missing case. *Verification* is a binary variable indicating whether an actor is a verified organizational account. The majority of our study actors (89.5%) have been verified in Weibo's official verification system. These consist of 114 verified organizational accounts and 23 verified individual accounts.

Second, issue-specific knowledge is also a significant predictor for communication ties. As early as Katz's two-step flow theory (1957), communication scholars have long recognized the critical role opinion leaders play in spreading information and shaping public opinion. In social media-based discussion networks, opinion leaders are influential information hubs even though they don't necessarily produce content directly (Choi, 2015). For many people, climate change is not only a psychologically distant issue (Spence, Poortinga, & Pidgeon, 2012), but also a complex topic packed up by different or even contested frames (Anderson, 2009). It is reasonable to assume that people would turn to climate change experts or opinion leaders with specialized knowledge on issues related to climate change. In this study, we focus on three fields that are closely related to climate change issues (i.e., environmentalism, climate science, and energy) and control for the higher likelihood of these expert actors in attracting more attention in climate communication on Weibo.

Expert is a binary variable that reflects actors' involvement in specialized fields related to climate change. An actor is considered an "expert" if their account description mentions keywords related to environmentalism, climate or meteorological sciences, and energy development. Out of the 153 study actors, 101 (66%) are classified as experts.

In modelling behaviour dynamics, we also control for alternative explanations to adequately examine how communication network ties influence individuals' participation behaviours. As represented by the abundant body of research on the communication mediation model theory (e.g., McLeod, Scheufele, & Moy, 1999), a growing consensus in the political communication literature is that civic engagement is contingent on individuals' intrinsic characteristics and that political interest is one of the most important drivers behind political engagement. Numerous studies have shown that the communication's empowering potential of

civic engagement is stronger and more consistent for people who are more interested and knowledgeable in public affairs than for politically apathetic individuals (e.g., Cho et al., 2009). A survey conducted in mainland China found that political interest has a consistent, strong modification on the role of social media use in public discourse and civic engagement (Ye, Xu, & Zhang, 2017). In the specific context of climate change, studies have also shown that people with higher interest in climate politics and knowledge about climate change tend to be more likely to engage in the online discourse about climate (Arlt et al., 2018; Taddicken & Reif, 2016). Therefore, we control for individuals' interest in climate change issues when model their participation behaviour dynamics.

Climate change interest is a binary variable that reflects an actor's level of engagement with the climate change discourse on Weibo, in relation to their overall activity level on the platform. To determine whether an actor has relatively high interest, we calculate the percentage of climate change related posts out of all their posts on Weibo, and actors whose percentage is above the median are classified as having high climate change interest.

4.3. Methodology

4.3.1. Longitudinal network analysis

We employ Stochastic Actor-Oriented Models (SAOMs) (Snijders et al., 2010) to analyse the co-evolution of the climate change communication network and individuals' participation behaviours in debating climate policies on Weibo. A key advantage of using SAOMs lies in their ability to explicitly formalize the joint evolution of network ties and individual characteristics (Steglich, Snijders, & Pearson, 2010). With two interdependent equations, we estimate temporal changes in communication network composition and individuals' participation behaviors

concurrently to examine the mutual influence between communication and participation within the network structure. By distinguishing the time sequence of different directions of influence, the SAOMs approach offers a statistically rigorous method to help us disentangle network selection and network influence processes in the co-evolution of communication and participation, while controlling for other relevant endogenous and exogenous factors. The estimation was performed using the R package *RSiena* (version 1.3.11) (Ripley, Snijders, Boda, Vörös, & Preciado, 2021).

4.3.2. Data

Weibo data was collected using a three-step snowball sampling approach. We started with a group of seed accounts (n = 245). The selection of seed accounts involves several criteria aimed at ensuring a more representative starting point for our sampling process. These included activity level (i.e., accounts consistently engaged with climate change topics but with varying frequencies of posting over the past year), engagement level (i.e. accounts demonstrated varying degrees of audience engagement, as evidenced by the number of likes, shares, and comments on their climate change-related posts), diversity of perspectives (i.e., accounts were searched from categories including ENGOs, scientists, government bodies, business, and ordinary citizens), verification status (i.e., included both verified and non-verified accounts). We collected these seed actors' publicly accessible posts between 2019 and 2021 that contain the keywords "气候变化" (climate change) or "全球变暖" (global warming). We extracted the usernames they mentioned or reposted in these posts. Next, we identified usernames who were mentioned or reposted by at least three seed users. These usernames were added to the account roster and their climate change-related posts were collected in order to search for other relevant usernames. We

repeated this iterative searching process until no new username emerged. The full roster includes 811 unique accounts. Since our research objective is to analyse the longitudinal co-evolution of communication and participation, the last sampling step narrows the account list down to focus only on actors who have exhibited persistent engagement in both online communicative interactions and expressive participation behaviours (i.e., actors who were involved in both interaction activities and content generation about climate change issues throughout all three years between 2019 and 2021). The final study sample comprises 153 actors.

A network was constructed based on reposting[8] and mentioning interactions among the 153 actors. Reposting often serves as a form of endorsement or a catalyst for further discussion, indicating agreement or importance placed on the shared content. Mentions, on the other hand, signal a direct engagement with or acknowledgment of specific users, often reflecting prior interactions, perceived relevance, or authority on the subject matter within the context of the discussion. Compared with examining the often-studied follower networks alone, this dual approach allows us to capture both content-driven (via reposts) and actor-driven (via mentions) influences (see also Cha, Haddadi, Benevenuto, & Gummadi, 2010). This allows us to study a higher level of online engagement and direct information/attention exchanges that are essential to both the influence and selection processes. The resulting network is a directed three-wave longitudinal network. The tie from actor i to j (x_{ij}) in wave t indicates a communicative relationship from i to j, that is i reposted j's climate change-related post(s) or i mentioned j in their post(s). Since SAOMs are better suited for analysing stable relationships than transient ones (Snijders et al., 2010, p. 45), we aggregated the numbers of reposting and mentioning activities

[8] Weibo's repost feature facilitates content dissemination in a sequential, chain-like manner, allowing users to see those who were recently involved in the post's sharing trajectory down the line. For the purposes of our study, we focused exclusively on the most recent reposting activity as it signifies the immediate connections and direct interactions in the communication network. See Appendix 3-D for an example of a Weibo reposting chain.

between two actors by year so that their network tie reflects a state of connectedness in online public discourse, rather than any episodic communication event. Because *RSiena* operates on unweighted ties, we dichotomized the network, setting $x_{ij} = 1$ when at least one tie existed in the given time wave and $x_{ij} = 0$ if none. This means our network analysis does not account for the increase or decrease of interaction frequency. Instead, it focuses on modeling the presence/absence of a connection between actors within the communication network over years. The direction of ties was retained, meaning that $x_{ij} \neq x_{ji}$. Self-loops (x_{ij}, $i=j$) were excluded, as reposting/mentioning oneself is not a meaningful communicative interaction. Figure 4-1 provides a visualization of the network structure in each wave.

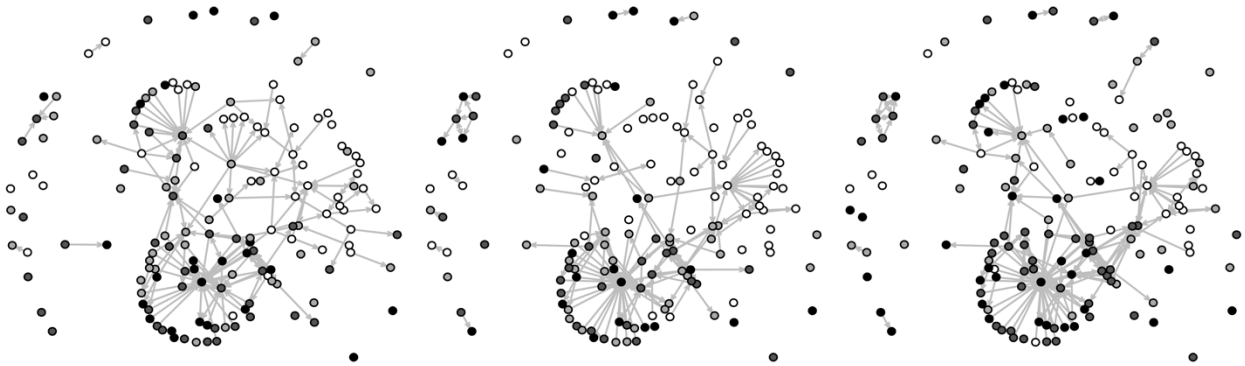


Figure 4-1 Network visualization of interaction relationships in wave 1 (left), wave 2 (middle), and wave 3 (right).
Note. Node colour indicates actors' participation level, with darker colours representing higher levels. Edge arrow indicates the direction of relationships.

The online expressive participation level is measured as the proportion of policy-related posts among all the posts an actor generated to discuss climate change. Our decision to employ a proportional measurement approach is driven by the need to address the multifaceted nature of climate change discourse, particularly the delineation between political (policy-related) and non-

political discussions (e.g., popular science, environmental campaign, personal experiences). This focus on policy-related posts is based on the assumption that such discussions represent a deeper, more targeted and engaged form of participation that holds direct implications for the societal responses, governance, and actionable solutions to climate change challenges. By measuring the proportion of policy-related posts within an actor's overall climate change posts, our analysis examines the extent to which actors are *politically* engaged with climate change issues, focusing on the quality, rather than the volume, of this engagement.

We employed a computational text analysis approach to determine whether a post discusses climate policies. First, we trained a structural topic model using the corpus of climate change posts (n = 75,126) generated by all roster accounts. The topic model detected 84 main topics from the public discussion corpus, which were then manually labeled based on high probability words and representative texts (the methodological details of the topic modelling method and the coding results, including keywords and example post texts, are provided in Appendix 3-A). Among the 84 detected topics, 33 pertained to climate change policy issues[9]. After determining post topics, we calculated the percentage of an actor's policy-focused posts in all the climate change posts they generated within each year. Finally, we categorized the values by transforming the numeric percentages into four ordinal levels: "low participation" (below 25%), "moderately low" (25% to 49%), "moderately high" (50% to 75%), and "high" (above 75%). The resulting data comprises a three-panel ordinal variable *participation level*, which will serve as the dependent variable when modelling behaviour dynamics and will be used as a time-varying independent variable when modelling network dynamics.

[9] Policy issues include the emissions trading system (ETS), Ecological Civilization, air pollution control policies, international climate politics, the Belt and Road Initiative (BRI), the Energy Conservation & Emission Reduction policy, green economy and finance, mitigation and adaptation actions, energy, and local public engagement.

Table 4-1 Descriptive statistics of network and behaviour dynamics.

		Wave 1	**Wave 2**	**Wave 3**
Network	Number of ties	164	173	209
	Network density	0.007	0.007	0.009
	Average degree	1.072	1.131	1.366
		Period 1 (Wave 1–2)		**Period 2 (Wave 2–3)**
	Jaccard similarity	0.272		0.447
Behaviour		**Wave 1**	**Wave 2**	**Wave 3**
	Low (=1)	30%	37.9%	22.2%
	Moderately low (=2)	26.8%	24.8%	22.2%
	Moderately high (=3)	26.8%	22.9%	32.7%
	High (=4)	16.3%	14.4%	22.9%
	Mean (SD)	2.29 (1.07)	2.14 (1.08)	2.56 (1.07)
	Mode	1	1	3

Table 4-1 provides the descriptive statistics of network ties and individual behaviour changes. The increasing number of ties, network density, and average degree show that the communication network grew in size and density over the three years. The Jaccard similarity index — an indicator of network stability — is above 0.25 for both periods, suggesting that tie changes between consecutive waves are gradual and sufficient for SAOMs simulation (see Ripley et al., 2021, p. 20). Behavior dynamics also remained relatively stable as shown by the overall average levels of participation over time. The model terms specified in our network–behaviour co-evolution model, including both network structure-based endogenous effects and actor attribute-based exogenous effects, are listed in Appendix 3-B. Finally, to account for time heterogeneity in our dataset, we included an interaction term between the time dummy variable and the participation level linear shape effect. Goodness-of-fit test was assessed based on indegree distribution, outdegree distribution, and geodesic distance distribution (see Appendix 3-C for GOF figures). The model was well converged, with an overall maximum convergence ratio of 0.23 and all estimates' convergence t ratios lower than 0.07.

4.4. Results

The results of our network–behaviour co-evolution model (Table 4-2) generally corroborate the RSM and support the mutual influence hypotheses, while revealing important nuances of the interplay between online communication and expressive participation. Our findings highlight the importance of structural network factors in driving the co-evolution of actors' communication relationships and their individual participatory behaviours.

Table 4-2 Longitudinal network and behaviour co-evolution model results.

	Effects	**Full Model**	
		par.	(s.e.)
	Network dynamics		
	Interaction rate (period 1)	3.370	(0.487)
	Interaction rate (period 2)	1.717	(0.199)
	Outdegree	–7.432 ***	(0.452)
H2a	Participation ego	0.142	(0.138)
H2b	Participation alter	–0.325 *	(0.160)
H3	Participation similarity	1.514 **	(0.532)
	Reciprocity	3.690 ***	(0.525)
	Transitive triplets	1.285 ***	(0.247)
	Indegree popularity (sqrt)	0.883 ***	(0.097)
	Outdegree activity (sqrt)	0.857 ***	(0.135)
	Indegree activity (sqrt)	–0.797 **	(0.290)
	Follower size alter	0.513 **	(0.167)
	Verification alter	1.300 †	(0.691)
	Expert alter	–0.674 ***	(0.204)
	Behaviour dynamics		
	Participation rate (period 1)	1.419	(0.228)
	Participation rate (period 2)	1.749	(0.365)
	Participation linear shape	–0.000	(0.201)
	Participation quadratic shape	0.197 †	(0.118)
H1a	Outdegree	–0.134	(0.103)
H1b	Indegree	0.004	(0.045)
H4	Average similarity	6.229 †	(3.378)
	CC interest	–0.023	(0.253)
	Time dummy (period 2)	1.190 *	(0.466)
	Model convergence All convergence t ratios < 0.06 Overall maximum convergence ratio 0.17		

	† p < 0.1; * p < 0.05; ** p < 0.01; *** p < 0.001

First, at the individual level, our model reveals no significant association between the monadic covariates of the number of network ties and the level of participation over time. Specifically, a higher *participation level* does not predict one's likelihood to initiate network ties in the subsequent time point (H1a) and is even negatively correlated with the likelihood of receiving ties from others in the communication network (H1a). Likewise, neither network *out-degree* (H2a) nor *in-degree* (H2b) centrality predict one's future *participation level*, suggesting being active or popular in the communication network does not necessarily impact individuals' participation behaviours.

However, a different picture emerges when we focused on the dyadic level. We find that *participation similarity* is a strong predictor of network ties at a later time point. This supports the behaviour homophily-based network selection hypothesis (H3) and indicates that actors tend to select discussion partners with similar participation levels. We also found a weaker but still significant effect concurrently working in the reverse direction. With actors' *climate change interest* controlled, the model shows the *average similarity* parameter is positive and statistically significant at the 0.1 level. The presence of network ties increases the likelihood of actors to adopt similar participation levels later, as their participation behaviors are likely to converge towards the average level of their discussants in a later time point. This lends support to the network influence hypothesis (H4) and suggests that network ties can influence individuals to adopt similar participation levels over time.

The two findings together offer intriguing insights into the communication–participation co-evolution mechanism. The non-significant findings for H1 and H2 suggest that individuals' general engagement and their popularity/activity within the network do not predict changes of

each other at the monadic level. This challenges the conventional interpretation of the RSM that more communication leads to more participation and vice versa. Instead, the findings about homophily at the dyadic level (H3 and H4) indicate that actors tend to form ties with others who have similar levels of participation, and these ties, in turn, lead to a convergence in participation levels over time. This implies a subtler, yet significant, form of co-evolution between communication and participation that operates through the selection of similar partners and subsequent mutual influence, rather than through direct, individual-level increases in participation leading to changes in network position or vice versa. These findings underscore the importance of looking beyond individual actions to network patterns in order to understand the dynamic interaction between communication and participation on social media.

Second, model results offer strong support for all hypothesized endogenous network structural effects. The positive and significant coefficients for *reciprocity* and *transitivity* indicate that actors tend to reciprocate online relationships and form direct relationships with their discussion partners' contacts in the network. The positive and significant *in-degree popularity* parameter suggests that actors tend to send ties to those already well-connected in the network, which is consistent with the preferential attachment principle. Regarding the impact of network connectedness on future communication activity, model results show that *in-degree* is negatively correlated with the likelihood of initiating ties at the subsequent time point, while *out-degree* is positively correlated. These degree-based findings imply that, in the Weibo climate change communication network, active actors tend to maintain a high level of activity, whereas popular actors, although increasingly accumulating more in-coming ties over time, tend to be less active in initiating new relationships in the long run.

Thirdly, the results of the control variables yield interesting findings about actors' popularity in the climate change communication network. On one hand, as expected, popularity is positively predicted by follower size and official identity verification status, with greater digital prestige correlating with an increased likelihood of being reposted or mentioned by others. On the other hand, contrary to our expectation that expert actors would be more popular in the network, the negative and significant *expert alter* parameter suggests that expert actors are less likely to be chosen as discussion partners compared to non-expert actors. This finding challenges expectations that expert actors, with their specialized knowledge, would naturally emerge as influential opinion leaders in climate communication. In legacy media, people's expertise has been a key factor in establishing them as opinion leaders (Katz, 1957). However, actors' influence and popularity on social media may be determined by new and more nuanced factors such as access to first-hand information (Walter & Brüggemann, 2020). The diffusion of social media influence away from experts might be seen as a double-edged sword. On one hand, it may reflect a transition towards a more democratized form of influence, where the authority to define and shape discussions on issues like climate change is no longer dependent on formal expertise, but is influenced by a broader array of factors and dispersed across a wider range of actors. On the other hand, it may also indicate a more populist form of influence that can feed into ideological polarization if influence is decoupled from the expert consensus of scientific epistemic communities.

4.5. Discussion and Conclusion

This study explores the dynamic interaction between climate change communication networks and online expressive participation in climate politics on China's Weibo social media platform.

Findings offer new insights into the dynamic interaction between digitally networked communication and online citizen participation. The analysis of network–behaviour co-evolution highlights the significance of the relational dimension and endogenous network factors that contextualize individuals' engagement in online communication and participation, which contribute to our understanding of the mutual influence between political communication and its attitudinal/behavioural outcomes as posited by the RSM theory. Our application of longitudinal social network analysis also demonstrates the methodological value of network approaches for helping us understand the bi-directional effects between political communication and participation.

Our results yield important insights that warrant further attention.

First, our findings suggest that the interplay between people's engagement in climate change communication and their expressive participation in climate policy debates does not equate to a straightforward reciprocation between "more network ties" and "higher participation levels." Rather, this interplay is characterised by homogeneity-based processes that combine homophilic network selection and influence dynamics. The finding that homogeneous social relations play a more significant role than individualistic activities draws our attention to the importance of social relations in the mutual influence between online communication and civic participation. This finding has important practical implications. To encourage broader and more active public engagement in climate communication and politics, it may be more effective to focus on network-building strategies and fostering relationships among individuals, rather than solely producing and circulating content with the assumption that more communication will directly translate into greater participation.

Findings on the asymmetric effects of influence and selection also add nuance to our understanding of communication–participation interplay in online environments. We found that network selection is stronger than network influence in climate change communication in terms of the magnitude of effect. This aligns with previous studies by Kruikemeier and Shehata (2017) and Lee and Xenos (2022) that report more pronounced effects of selection than influence in online communication. The former tend to be more evident in the online high-choice media environment because this environment provides users with abundant opportunities to select content or contacts based on their personal interests. Social influence effects may be overshadowed by this high controllability because social influence generally takes longer to unfold and operates at a slower pace. The imbalance may also be attributed to Weibo's platform culture. Weibo is primarily used by Chinese netizens to gather information or express personal opinions, rather than maintaining social relationships (E. L. Han, 2018). Given that public mobilization spreads more effectively through strong ties than weak ties (Bond et al., 2012), connections on Weibo, which mainly comprise of information- or opinion-oriented weak ties, may exert a limited impact on altering individuals' opinions and behaviors significantly.

Our findings on homogeneity-based reinforcement spirals, characterized by a more pronounced homophilic network selection effect in digitally networked media environments, holds important implications for political participation and civic engagement. While homogenous networks are likely to encourage and sustain collective action, affirmative communication may also undermine trust in out-groups while still fueling participation. Homogenous networks in a fragmented online media environment may risk exacerbating social divisions when partisan political beliefs and identities are involved. This bears special relevance to the issue of climate change, which has become increasingly politicized (Chinn et al., 2020). We have seen

polarization of climate change perceptions, beliefs, and related public policies emerging in online media environments like Twitter (e.g., Jang & Hart, 2015; Williams et al., 2015). While the Chinese climate change discourse is less polarized compared with that in anglophone countries (J. Yang et al., 2021), increasing homogeneity within one's online networks could still raise concerns. These behaviour-based reinforcing spirals may pull apart the participatory actors and those indifferent to climate politics, impeding much-needed progress towards mobilizing broad public participation in climate mitigation and adaptation.

This study has limitations that merit further investigation. First, to ensure data completeness for SAOMs simulation, we focused only on a small group of actors who consistently participated in climate policy discussions on Weibo between 2019 and 2021. This approach excluded less persistent participants and "lurkers," who likely constitute the majority of Weibo's user base. Nevertheless, we view this trade-off as acceptable given the study's innovative application of SAOMs to examine network structural effects in the reinforcing spirals, a facet often overlooked in prior RSM studies. Future research could leverage insights gained from this small and core group of actors to develop analytical frameworks that are applicable to larger, more diverse datasets. This could include, for instance, incorporate the less active participants and compare their interaction patterns, to achieve a more comprehensive understanding of communication – participation reinforcement across different actor groups.

Second, our model did not account for factors such as political self-efficacy, personality traits, socio-demographic variables, or message-level elements like discussion topic and sentiment, all of which may affect individuals' engagement and participation. Future research should consider developing more comprehensive models that integrate these factors. Lastly, the generalization of our results may be limited by China's unique sociopolitical context and climate

change discourse. Future research should extend the analysis to other societal contexts and other topic issues.

A final note is that the concurrent network selection and network influence processes identified in this study should not be misconstrued as bi-directional causality between communication and participation. Although our longitudinal analysis helped elucidate the temporal order of effects between network and behavior dynamics, causality in social networks cannot be established based solely on temporality (see also Lomi, Snijders, Steglich, & Torló, 2011). Moreover, as Slater (2007) argues, rather than a straightforward back-and-forth relationship, the mutual influence in the reinforcing spirals model should be better conceptualized as a cumulative effect that progresses over time (pp. 283–284). As such, our network–behaviour co-evolution analysis does not provide a complete test of causality in reinforcing spirals as theorized in RSM theory. Despite of this limitation, the study offers a promising starting point for examining the mutual influence between communication and participation within social network context. We encourage further research to delve deeper into these network forces to enrich our understanding of the intricate dynamics between digitally networked communication and citizen participation.

5. Chapter 5 Conclusion

In September 2020, Chinese President Xi Jinping proposed the "dual carbon goals" at the 75th session of the United Nations General Assembly, setting ambitious goals to peak CO_2 carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060 (Xinhua News, 2021). This initiative is a significant part of China's efforts to address climate change and transition towards a more sustainable and environmentally friendly development model.

China stands out as a pivotal actor among the constellation of nations grappling with the global challenge of climate change. As the world's largest greenhouse gases emitter by volume (though not per capita), China's climate actions and policies have far-reaching ramifications for the global endeavor towards decarbonization. On one hand, China's rapid economic development over the past few decades has led to unprecedented urbanization and industrialization, alongside significant energy consumption and serious environmental pollution, including its massive carbon footprint. On the other hand, the country has also undertaken substantial strides towards climate change mitigation, as demonstrated by the enactment of critical environmental and climate policies in recent years such as substantial investments in renewable energy, the rapid phase-out of coal-fired domestic power plants, and the implementation of ambitious afforestation and ecosystem-based carbon sequestration projects. These underscore China's complex role as both a major contributor to global greenhouse gas emissions and an important player in the international effort to curb climate change.

Tackling climate change requires comprehensive measures across diverse social sectors, alongside investing substantially in green and low-carbon technologies, strengthening legal and policy frameworks of environmental governance, and fostering international cooperation on

climate change initiatives. As such, China's proactive climate actions over the recent decade extend beyond merely influencing the environmental domain to areas such as technological innovation, economic restructuring, governance reforms, and socio-cultural shifts. Moreover, China's burgeoning influence on the global stage solidifies its position as a crucial player within the global climate regime and the broader sphere of international climate politics. China's commitment to assuming a greater share of responsibilities in combating climate change aligns with the country's strategic objective to redefine its role in international affairs, positioning climate cooperation as a pivotal domain for showcasing its leadership, particularly among developing countries.

The uniqueness of China's polity, society, and multifaceted role in climate change invites researchers to delve deeper into the specific cultural, economic, and political contexts that shape its environmental policies and public discourse. Understanding these unique aspects is essential for us to develop targeted and effective strategies that address both local and global climate challenges. As highlighted by Zinda et al. (2018b), China's experience, specific institutions, discourses, and global position challenges major currents of thought in environmental sociology that predominantly focus on liberal polities in the global North and often oversimplify the complexities of the global South. This context compels us to expand the scope of environmental sociology to include more nuanced, culturally sensitive, and globally inclusive theories that address the distinct characteristics of nations like China.

Acknowledging these uniqueness and complexities, I argue that an in-depth analysis of the dynamics of climate communication, public engagement, and environmental governance — which are indispensable elements in steering us towards a more environmentally sustainable future — is not just relevant but essential. In the concluding chapter of this dissertation, it is

important to reiterate the significance of achieving a nuanced and comprehensive grasp of the intricacies of climate change communication in China, and to discuss how these findings can potentially transform the Chinese public's approach to climate action and contribute to a more effective global strategy for addressing the urgent challenge of climate change. The insights gleaned from the Chinese case holds both theoretical and practical implications, offering valuable perspectives for shaping policy, enhancing international cooperation, and propelling the global community towards a pathway of sustainability and environmental resilience.

In this dissertation, I have delved into public discourse on climate change to explore the nuances of public engagement and communication against the backdrop of China's distinctive socio-political landscape. China's climate actions are often characterised by state-led initiatives, embodying a "top–down model" as highlighted by scholars such as Beeson (2010), Gilley (2012), and Huang & Liu (2021). This prevalence of state-centric approaches, amidst the complex dynamics of challenges and opportunities in climate change mitigation and adaptation, underscores the need for a comprehensive examination of the construction, dissemination, and reception of climate change discourse among the broader public in China. The consequences of public engagement significantly impacts global efforts towards climate mitigation and adaptation. Significant changes can be driven by informed and engaged publics, such as pushing for stricter environmental regulations, adopting sustainable practices, and supporting green technologies. Public engagement influences policymakers to commit to enforce climate goals and policies that reduce carbon emissions and enhance resilience against climate impacts. Conversely, the absence of public engagement can lead to a lack of awareness and urgency, resulting in inadequate policy measures and slower progress in combating climate change.

Therefore, it is important to investigate Chinese public's approach to communicating and engaging with climate change discourse, as well as the array of factors that shape public attitudes, behaviors, and perceptions towards climate change within China's unique socio-political context. This investigation also holds important practical values. It helps devise effective public communication and engagement strategies that consider and resonate with the diverse perspectives. Moreover, it informs the development of more inclusive, culturally and contextually sensitive, and effective environmental governance approaches in China. These can contribute to meaningful global climate change responses.

Specifically, through three research manuscripts, this dissertation has delved into the multifaceted dimensions of climate change communication on China's top social media platform Weibo. It has examined social interaction relations among actors, discursive association relations among concepts, and the dynamic interplay between these social and ideational relations over time. The insights derived from these studies contribute to several areas of scholarship. They extend our understanding of social media's role in public communication, offer detailed case studies of how the specificities of environmental discourse and climate politics manifest in the important yet understudied Chinese context. This dissertation makes methodological contributions by demonstrating the application and value of innovative analytical methods that utilize network-based and data-driven approaches to uncover patterns and trends in large-scale multidimensional digital datasets.

5.1. Findings & Applied Contributions

5.1.1. Information flows & interaction structures in climate communication networks

In the first manuscript, I investigated information flows and interaction relationships in the online public discussion around two key IPCC reports, focusing specifically on analysing how individual users interact with state and elite actors on Weibo. Using social network analysis methods, I examined the structure of these communication networks, delineated the paths of information dissemination among various user groups, and compared how these patterns of information diffusion changed before and after the 2015 Paris Summit. The findings reveal a generally promising trend: an increase in public engagement and a broader variety of perspectives within the climate change discourse, evidenced by the growing prominence of individual users in these networks. This indicates an escalating interest and participation by the public in climate change discussions on Weibo. However, the analysis also identified three restrictive tendencies that limit Weibo's potential to facilitate two-directional public engagement and open deliberation around climate change issues. These include the decrease in balanced dialogic interactions, the insufficiency of bottom-up information flows, and the increase of homophily among elite and governmental users. These findings contribute to a nuanced understanding of China's online green public sphere (G. Yang & Calhoun, 2007) and the Chinese public's "greenspeak" (Y. Sun et al., 2017) in their everyday use of Weibo, illuminating the complexities, opportunities, and challenges Weibo presents as a platform for citizen communication and engagement with climate change discourse.

These findings have valuable practical implications. On one hand, the expansion of public engagement and the diversification of climate frames on Weibo indicate its capacity to serve as a vibrant space for articulating diverse views on climate change. As individual users gain more

influence in communication networks, we expect to see more personalized frames and narratives emerge to balance the dominance of elite-driven discourse in China's climate change conversation. These underscore Weibo's role in helping individuals to voice their experiences and concerns about climate change. Moreover, findings of this study also demonstrate the value of studying the relational structure of citizen–government interaction in climate communication. Better understandings of these relational structures can help to cultivate a more active and informed environmental civil society and improve transparency and responsiveness from authorities concerning climate policies. These, in turn, can contribute to the development of a more inclusive and participatory model of climate governance.

Yet, several network structural constraints have been identified within Weibo's climate communication networks. The decrease of mutually balanced interactions poses challenges to fostering constructive public deliberation and achieving truly diverse and inclusive public engagement. The insufficiency of bottom-up information flows could hamper the effective dissemination of perspectives and information pertinent to local and grassroots contexts. Furthermore, the prevalence of homophily among elite and governmental users not only obstructs meaningful citizen–government interactions on Weibo but also raises the risk of creating echo chambers that hamper the diversity of viewpoints crucial for crafting inclusive policies. Addressing these issues is critical for ensuring a wider spectrum of perspectives can be presented and deliberated in climate communication on Weibo, thereby vitalizing the online green public sphere and cultivating more inclusive, participatory, and responsive dynamics between citizen and government in shaping climate discourse and policies.

5.1.2. Aligning environmentalism and development in public discourse on climate change

In the second manuscript, I investigated the dynamics of online climate change discussions between 2009 and 2019 on Weibo. Specifically, I used a combination of topic modelling and network analysis methods to examine development- and environmentalism-oriented topics' public visibility on Weibo, the network structure of their co-occurrence relationship in individuals' online expression, and the temporal evolution of their prevalence in terms of diagnostic, prognostic, and motivational framings of climate change. This study showed that public discussions on climate change are largely framed through a development-oriented environmental discourse, which underscores the convergence between environmental protection and national development as catalysts for pro-environmental actions, green energy transitions, and low-carbon development. Pronounced and close interconnections exist between environmentalism and development topics in individuals' online expressions. While environmentalism topics tend to be more expansive, development topics exhibit a higher degree of network centrality, thus attaining greater prominence in the online public discourse on the relational dimension.

As the global climate policy architecture becomes increasingly fragmented, complex, and decentralized in the post-Copenhagen era (Bäckstrand & Lövbrand, 2019), moving beyond perspectives rooted in the Global North and acknowledging the specifications of how climate change issues are perceived and communicated in varied social contexts is crucial for deepening our understanding of the global "varieties of environmentalism" (Guha & Alier 2013). This study represents a concrete step towards this exploration. The finding on the prominence of developmental environmentalism in public discourse suggests that the Chinese public on Weibo

embraces a non-dichotomous understanding of the nexus between environmentalism and developmental pursuits concerning climate change. For developing countries, where the urgency of climate action often competes with or is overshadowed by the imperative for local socio-economic prosperity, framing climate change within the broader narrative of national development can serve as a strategic approach to garnering public support for climate policies across diverse societal groups. Thus, the insights gleaned from this study not only shed light on the nuanced public understanding of climate change in China but also illuminate the country's recent pivot towards more assertive pro-environmental initiatives and proactive climate change measures. These measures adeptly intertwine environmental concerns with the overarching developmental strategy, offering an explorative model for integrating environmental sustainability within the pursuit of socio-economic prosperity, which could serve as a blueprint for other developing countries navigating similar challenges.

This study also carries practical implications for NGOs, environmental communicators, and policymakers. Recognizing the prevalence of developmental environmentalism in climate discourse on Weibo can help practitioner in the environmental sector to craft messages that effectively align environmental objectives with developmental goals to evoke broader resonance with the Chinese public. This strategic alignment facilitates the framing of environmental initiatives in a way that underscores their compatibility with, and contribution to, local economic sustainability. Consequently, this insight can guide the formulation of environmental policies, especially those align with public concerns and aspirations on local economic sustainability, to enhance public acceptance and support among diverse social groups. It may also help international bodies and NGOs to garner public support and achieve concrete impacts in their climate change initiatives within China, thereby contributing to more effective international

collaborations and negotiations. This research, therefore, not only contributes to the climate change discourse literature, but also provides valuable and actionable insights for enhancing public climate communication strategies in China and other places that share a similar socio-political context.

5.1.3. Reinforcing spirals of online public engagement with climate policy debates

In the last study of this dissertation, I investigated the co-evolution of climate change communication networks and individuals' expressive participations in online climate policy debates between 2019 and 2021. Results of this study provide empirical support for the Reinforcing Spirals Model (RSM) theory's key proposition on the mutual influence between communication and participation. More importantly, with a novel application of longitudinal network method on communication–participation interaction analysis, this study highlights the critical role social relations play in bridging this reinforcement process.

The RSM theory posits a feedback loop where consuming specific media content or engaging in discussions with individuals who hold certain opinions lead individuals to develop corresponding viewpoints, which, in turn, can lead to further communication activities that align with this newfound stance. Using the Stochastic Actor Oriented Model (SAOM) method, this study provides empirical evidence for such a reinforcement relationship in climate change communication and participation, and extends RSM research with three nuanced insights. First, at the individual level, actors' participation behaviour and their activity/popularity in the communication network over time do not positively predict each other. Instead, they are connected through the reinforcement of participatory behaviour (or lack thereof) within one's social networks in online communication. Second, the model shows that significant homophilic

network selection and network influence towards homogeneity exist concurrently, and that the selection effect is probabilistically more evident in explaining the communication–participation co-evolution observed in our Weibo dataset. Third, results of this study highlight the significance of endogenous network structural factors in predicting people's engagement in climate change communication, as online communicative interactions tend to follow network propensities including reciprocity, transitivity, and preferential attachment and are influenced by degree centrality.

This study contributes to the literature of digital media-based public communication and citizen participation. Drawing on climate communication data on Weibo, it provides empirical support for RSM and underscores the reciprocal impact between political communication and its effects on attitudes and behaviors — even within China's socio-political context where public participation is rather limited. More importantly, this study goes beyond reaffirming RSM's foundational claims. Model results refine existing RSM theory by questioning the presumption that an individual's activity/popularity within a communication network directly leads to increased long-term participation. The finding on the concurrent homogeneity-based network selection and influence processes underscores the pivotal role of social relationships in bridging the reinforcing spirals between online communication activities and subsequent participatory actions. This challenges traditional linear models of online influence/selection and highlights the importance of considering the social relational dimensions in public communication and civic participation studies. As such, this study not only contributes to the literature of the Chinese public's engagement with climate change politics, but also makes important theoretical contributions to the broader literature on political communication, offering a more nuanced

understanding of the role and mechanism of digital media-facilitated public communication in shaping people's engagement with public/political issues.

Beyond theoretical contributions, this study also offers practical implications for stakeholders seeking to harness online communication for enhancing public engagement. Understanding the mutual influence between online communication and public participation — and the critical role of social relations in bridging these dynamics — can help policymakers to develop more targeted and effective strategies to promote the public's engagement with climate policies and other public issues, thus fostering greater transparency and responsiveness in policy processes. Similarly, this can inform ENGOs and advocacy groups to develop more engaged environmental campaign messages and strategies. Recognizing that mere online visibility or activity does not automatically translate into more participatory behaviors, environmental groups are encouraged to focus on cultivating strong social connections and community ties in their online activities. Such strategic focus on building and nurturing social connections can amplify the impact of their efforts, ensuring messages not only reach but deeply resonate with their target audiences. Moreover, this research underscores the critical role social media platforms play in shaping the digital public sphere because of their power to design community-building features and algorithms. While social ties are instrumental in translating online activities into participatory behavior, the social network of politically apathetic communities can also lead to the formation of echo chambers that impede genuine public engagement and participation. This highlights the necessity for these platforms to thoughtfully engineer their community-building features and algorithms. By prioritizing features that promote diverse interactions and the building of meaningful social connections, social media platforms can play a pivotal role in

enhancing public discourse and participation, thereby contributing to more vibrant, informed, and engaged online communities.

5.2. Methodological Contributions

This dissertation demonstrates the methodological value of social network analysis methods (SNA) in exploring the relational dynamics among users within digitally networked media and in dissecting the intricacies of information dissemination in public communication research. Network methods can serve as powerful tools in social media research to offer a systematic and comprehensive analytical framework for studying the complex interaction relationships that characterize digital communication landscapes. Analysis in all three manuscripts shows how this quantitative and social relation-based methodological framework can be used to analyse social media data to delineate the complex network of user interactions, pinpoint key actors, quantify relational influence, and visualize the pathways through which information diffuses.

In the first manuscript, SNA was employed to answer questions such as how content spreads, who the primary disseminators are, and how certain actors gain prominence within the communication networks. The application of SNA in these analyses not only enhances our understanding of climate communication on Weibo, but also showcases the broader applicability and value of network analysis methods helping us unpack nuanced mechanisms of user interactions and information diffusion structures in digital communication.

The second manuscript's methodological contribution lays in its novel utilization of a computational text analysis approach that combines topic modelling and network analysis methods. Topic modelling — which is a data-driven approach to efficiently and systematically examine expansive textual datasets that characteristic of social media research — was employed

to analyse the trends and patterns in the Weibo climate discussions data spanning over ten years. Such an approach surpasses the capabilities of traditional content analysis methods, which may be too resource intensive due to the data's sheer volume. Network analysis enables the quantification and exploration of the complex relationships and interdependencies among various topics within the climate change discourse on Weibo, offering insights into the structural and relational aspects of public discourse that might be overlooked by conventional analysis techniques. By combining topic modelling and network analysis methods, this study was able to handle a large user-generated-content dataset and yield novel and comprehensive insights into online public discourse. This innovative combination is a valuable application for so-called big data research, where understanding the dynamics of digital communication requires both advanced computational tools and sophisticated analytical frameworks. As such, this study stands as a useful methodological example for future research to navigate and interpret the multifaceted landscape of digital communication data analysis with greater efficacy.

The third manuscript makes novel methodological contributions to RSM research through applying longitudinal network analysis on communication–participation interaction. Previous RSM studies have primarily adopted a methodological individualism framework, where communication activities are viewed as individuals' attributes and assessed through individualistic covariates. What has been generally overlooked is the social network structures that contextualize individuals' actions in communication and participation and thus people's interdependency in these activities. By employing the Stochastic Actor-Oriented Model, the third manuscript explicitly models the influence of the relational structure on people's communication activities, addressing the critical issue of interdependency that previous studies have largely overlooked. The use of longitudinal social network analysis not only contributes to the

methodological tools available for RSM research, but also brings to light the pivotal role of social networks in bridging the bi-directional effects between political communication and participation. Future research would benefit from such a network approach to explore the complex interplay between communication and participation and the mechanisms underpinning these dynamics.

Overall, this dissertation's application of network analysis, combined with computational text analysis and longitudinal network approaches, enriches our understanding of digital communication dynamics. Each manuscript contributes uniquely by leveraging these tools to uncover nuanced insights into content dissemination, actor prominence, and the intricate relationships between communication and participation on Weibo. By integrating these methodological frameworks with digital climate change communication research, analysis in this dissertation offers a comprehensive approach to studying large datasets that are characteristic of social media research, thereby enhancing our ability to interpret and leverage these online climate discourses and activities for more effective public engagement and communication strategies in response to climate change. As digital landscapes continue to evolve, the methodological applications demonstrated here provide a robust foundation for future studies to analyse the complexities of communicating critical public issues like climate change within the digital sphere.

5.3. Limitations

There are several limitations that warrant further investigation in future research. First, analysis in this dissertation focused on the case of Sina Weibo. With a reputation for public influence, Weibo is an important venue for the Chinese public to seek alternative information,

express political grievances, and mobilize non-confrontational collective actions (Han, 2018; Huang and Sun, 2014; Rauchfleisch and Schäfer, 2015). This public orientation makes Weibo an intriguing case for studying the new extra-institutional, decentralized, and networked mode of public participation in a country where institutional participation channels are largely constrained. However, by focusing exclusively on Sina Weibo, the findings may not be fully generalizable to other social media platforms or forms of digital participation within China. Other popular platforms, such as WeChat or TikTok, have different user demographics, features, and modes of interaction that could lead to varying dynamics of public engagement and political discourse. Weibo's specific regulatory environment and the recent commercializing trend of public discussion (see also E. L. Han, 2018) might influence user behavior differently. Therefore, future research should consider a comparative analysis across multiple social media platforms to capture a more comprehensive picture of digital public participation in China.

Another limitation of this dissertation arises from the non-representativeness of Weibo data concerning user identity. Weibo users tends to skew towards a younger, more educated, and wealthier demographic compared to the general population of China (Weibo Data Centre, 2021). Furthermore, the data collected through crawling Weibo user profiles are self-reported and self-selected, which introduces a bias towards those who choose to engage online and disclose information. Additionally, the data lacks comprehensive demographic details, which complicates efforts to generalize findings across the broader Chinese population. This skew in demographics and the incomplete nature of the data limit the applicability of our findings to all segments of the population, potentially overlooking the perspectives and behaviors of less represented groups who are, nevertheless, likely to be more vulnerable to the ecological and social risks of climate change. Future research should consider employing stratified sampling methods to represent a

broader spectrum of the Chinese population and focused methods that deliberately target less represented and potentially more vulnerable social groups. This could involve using more inclusive data from multiple social media platforms that are popular across different societal segments and partnering with ENGOs to access data from specific social groups.

Third, this dissertation relied on quantitative "big data" analysis. While this approach allows for the processing of large volumes of data, it can lead to a detachment from the essential contexts that imbue social media postings with meanings (Boyd & Crawford, 2012). With primarily statistical and computational methods, analysis in this dissertation prioritized quantitative trends and patterns over the qualitative nuances that can reveal deeper insights into user motivations, emotions, and cultural significance behind these trends and patterns. As a result, findings may oversimplify or misrepresent the dynamics of user engagement and the substantive content in climate communication. This abstraction can obscure the complex social, cultural, and political contexts that shape how individuals use platforms like Weibo to communicate the complexity of climate change issues. Therefore, future research should integrate qualitative methodologies to capture the rich contexts that quantitative methods alone cannot provide. In particular, future research should consider conducting in-depth interviews and focus groups with users to gain more nuanced insights on their motivations for engaging with online climate communication, their interpretation of climate messages, and the personal or societal impacts of online activities in relation to their climate actions in practice.

Furthermore, the rise of Artificial Intelligence (AI) since 2023 is increasingly transforming how content is curated, personalized, and delivered to users on social media. Due to the timeframe of my study, this dissertation did not discuss much about this rapid developing influence of AI in the social media sphere. However, AI-generated content and online activities

can significantly impact the public understandings of, the public sentiments in, and the dynamics of engagement in climate communication. As commented by Lahsen (2020), the needs and interests of wider publics can be overlooked when AI technologies reinforce the biases of privileged social groups such as white male engineers who design automated content-generating algorithms or capital elites behind the AI economy. This risks skewing the public perception of climate change issues and distorting the genuine engagement and responses of real users to socio-political dynamics around climate change. Studying the AI influence in, and its implications on, climate communication is therefore crucial for future research to provide a clearer view of the increasingly complex landscape of climate communication on digital platforms.

5.4. Discussion: Digitally networked participation & the depoliticization of climate change discourse in China

Digital media technologies have been pivotal in broadening the discursive field in China beyond the authorities, elites, and civil society organizations to include more ordinary citizens. By facilitating access to alternative information sources, enabling spontaneous discussions on matters of public concern, and influencing the shaping of public opinion, digital media serves as a vital conduit for civic deliberation and participation, as well as the development of public sphere within China's unique socio-political landscape (Bondes & Schucher, 2014, 2014; Cheng, Liang, & Leung, 2015; Lei, 2018; O. A. Lewis, 2013; Rauchfleisch & Schäfer, 2015; W. C. Reese Stephen D., 2015; Shao & Wang, 2017; Skoric, Zhu, & Pang, 2016; Y. Song et al., 2016; H. Wang & Shi, 2018; G. Yang, 2003). This is the space where citizens' online conversations and "surrounding gazes" (Teng & Mosher, 2020) on societal issues aggregate into a wider public

discourse. This is also the space where citizens' individualistic public/political expressions become transformed into communicative actions in digitally networked participation. This new extra-institutional, decentralized, and networked mode of public participation — the new way of being political, as commented by scholars such as Bennett (2012) and Theocharis (2015) — has important implications within a context where offline participatory opportunities are notably limited.

Throughout this dissertation, I demonstrated the value of studying individuals' online expressions and communicative interactions around climate change issues in helping us better understand digitally networked participation in China's online green public sphere — a space where the publics gather to articulate their views on, understand shared concerns of, and produce and consume discourses about environmental issues and policies. With novel analyses on the network structure of information flows, discursive characteristics of public discussion, and the dynamic interplay between communication and participation, each of the three studies in this dissertation offers valuable insights into the nuances and dynamics of Chinese citizens' digitally networked participation in climate change discourse.

The first manuscript emphasizes the value of studying the network structure of information flows in advancing our understanding of the green public sphere. Findings on the interaction patterns between individual users and state/elite actors in climate change communication suggest both opportunities and challenges of the Weibo platform in facilitating an online environment conducive to diverse and open deliberation on climate change issues. While the first manuscript analyses the network structure of information flows, the second manuscript focuses on the content that flows through these networks. The finding that developmental environmentalism stands out as a prevalent theme in public online discussion points to the cultural sensitivity of

climate discourse in the Chinese society. Recognizing this discursive underpinning is important for us to better understand the motivation of citizens' engagement with climate discourse and thus shedding lights on the pathways to enhance the participatory quality of the green public sphere. The third manuscript's longitudinal network analysis illuminates the mutual influence between people's engagement with online communicative interactions and their online participatory behaviour over time, highlighting the relational dimension in this interplay. Findings underscore the critical role of social networks in shaping individuals' participatory behaviors and that of social connectedness in translating personal activities into civic actions in online public participation.

Together, these three manuscripts illuminate the multifaceted ways in which Chinese citizens engage with, contribute to, and are influenced by climate communication and participation in the digital space. Despite the diversity of the three studies' focal points — from the structural and content aspects of information flows to the social dynamics that drive engagement — a common theme emerges to highlight the critical role of the new extra-institutional, expressive, individually initiated but socially connected online activities in cultivating an inclusive, dynamic, and participatory green public sphere in China. By unraveling the complexities of digital networked participation against the backdrop of China's unique socio-political context, insights gleaned from this dissertation provide a richer and more nuanced understanding of how Chinese citizens' engagement with climate discourse and politics unfold in the digital space. These insights encourage policymakers, activists, and scholars alike to consider how these digital networked participation practices can be harnessed to nurture a more informed, engaged, and responsive citizenry in the face of global environmental challenges.

In addition to the converging theme of digitally networked participation, my exploration also uncovers another critical layer spanning across all three studies that warrants further discussion — the pronounced influence of state actors and the predominance of official environmental narratives within the green public sphere. Throughout this dissertation, I observed that government-driven narratives intersect with, and at times, redefine the boundaries of public engagement in environmental discourse. The presence and influence of state actors in online green public sphere not only guides but also shapes the contours of public communication and participation, leading to a distinctive characterization of China's climate change discourse. This pervasive influence of the state is evidenced by findings including the dominant role of state media and governmental entities in initiating climate information flows (Manuscript I), the prominence of national development-oriented topics in the public's online discussion on climate change (Manuscript II), and the pronounced homophily effect among governmental actors in the climate communication network (Manuscript III).

Such strong state influences are likely to narrow the spectrum of voices and limit the diversity of perspectives — factors that should ideally characterize a vibrant public sphere. In fact, as shown in Study II, individuals' climate expressions in their everyday use of Weibo do align closely with the official environmental narratives of Ecological Civilization promoted by the central government. The prevailing discourse of developmental environmentalism in public online discussions reflects more of a state-driven future imaginary where national development is prioritized over the wellbeing of individuals. This leaves little space for individuals to perceive the complex climate change issues from their own standpoints and with varied cultural and political perspectives. Such a grand and homogenized climate discourse not only narrows the

scope for diverse public engagement but also tends to centralize the agency and power to address climate issues within the hands of the central government.

However, the role of individuals in contributing to, and addressing, climate change is undeniably crucial. As reported in the China Statistical Yearbook 2023, the energy consumption of Chinese households amounted to 12.8% of the country's total energy consumption in 2021 (National Bureau of Statistics of China, 2023). This figure highlights the significant cumulative effect Chinese individuals' behaviors and households' choices have on global emissions. Moreover, individuals' perceptions of climate change and engagement with climate discourse shape their willingness and readiness to undertake not only personal initiatives within the private domain to curb carbon emission, but also have important impacts as they participate in the political arena.

Individuals' cognitive involvement and behavioural engagement are essential for spurring their civic actions to address environmental issues collectively and bolstering public participation in environmental policymaking and implementation processes. The PM2.5 pollution crisis in China serves as a prime case for exemplifying this potential. While China's environmental governance is often associated with Authoritarian Environmentalism, public outcry and active online engagement have effectively pressured the government to address ambient air pollution and enact meaningful air quality regulations (Ahlers & Shen, 2018). In contrast, we have not seen such a level of public engagement and its consequential impact on policy being mirrored in the context of climate change issues. This discrepancy may stem from the public's perception of climate change as a more abstract and distant issue compared to the immediate health impacts of air pollution. This perception is likely influenced by the prevailing discourse of developmental

environmentalism and the dominant role of state/elite actors in shaping this narrative, even within the realm of social media.

I argue that the prevailing influence of state actors and official discourse in shaping climate discourse in China reflects a form of depoliticization of climate change — a broader global trend identified by many scholars (e.g., Kenis & Lievens, 2014; Kenis & Mathijs, 2014; Macgregor, 2014; Machin, 2013; Maeseele, 2015; Pepermans & Maeseele, 2016; Swyngedouw, 2013). This trend sees climate change being depoliticalized in global mainstream communication through strategies such as scientization (i.e., foregrounding the scientific interpretation of climate change over other aspects of the issue), economization (i.e., prioritizing economic implications and solutions of climate change), moralization (i.e., appealing to ethical considerations), and naturalization (i.e., accepting the current capitalist system as an immutable context for exploring the pathways to climate sustainability) (Carvalho et al., 2017). These depoliticizing strategies constrain climate discourse as they limit both the understanding of climate change and the spectrum of climate actions considered viable within the confines of the status quo (Machin, 2013; Maeseele, 2015). Such approaches sideline the potential for transformative climate solutions (which would engender conflict among social groups and vested interests), opting instead for a consensus-oriented narrative over climate change issues. This leads to a "post-political condition" where climate change is naturalized as a "de-bounded risk" — a risk detached from its socio-political underpinnings (Rothe, 2011, p. 341). Through prioritizing economic and scientific technocrats' role in shaping our future imaginary, this post-political condition also discourages citizens' political engagement, relegating the public to passive spectators rather than active contributors to their own future (Carvalho et al., 2017).

Beyond the four strategies outlined by Carvalho et al. (2017), I argue that the pronounced influence of governmental voices over climate discourse introduces another layer of depoliticization within China's specific socio-political context. The dominance of developmental environmentalism in online climate discussions, as revealed in the second study of this dissertation, exemplifies this unique mode of depoliticizing climate change. Through emphasizing the opportunity for national development in climate mitigation and adaption processes, it promotes a future vision where economic growth and environmental sustainability can be mutually compatible without substantial changes to the existing operation of macro systems. This perspective is encapsulated within the Ecological Civilization framework, where allegiance to the Party-State's leadership is portrayed as the bedrock for achieving both material prosperity and effective climate action (see for example State Council, 2015a). This homogenized discourse leaves little space for individuals to act as the "primary definer" (Anderson, 2009) in climate change issues and discourages them to engage in politically challenging conversations that are critical for climate mitigation. Moreover, technological optimism underlying this development–environment synergy diminishes the urgency for critical debate on the structural causes of and other deeply rooted factors behind environmental and climate challenges. Consequently, uncritical acceptance of this future vision where sustainable development is achieved without significant systemic change neglects the need for deeper transformations essential for achieving long-term sustainability in response to the global climate change challenges.

This distinct form of depoliticization of climate change in China can be contextualized by considering the country's unique political environment and the non-confrontational tradition of its environmental movements. Unlike their Western counterparts, which often resort to direct

confrontations and media campaigns to advance their environmental advocacy, Chinese ENGOs have been found to strategically steer clear of political appeals for systemic reforms, but tend to focus on politically neutral activities, exercising self-censorship and emphasizing the importance of raising public awareness and fostering personal and commercial actions to address environmental issues (Dai & Spires, 2018; Ho & Edmonds, 2008; Lu, 2007; Spires, 2011; S.-Y. Tang & Zhan, 2008; Xie, 2009; G. Yang, 2005). This approach allows many Chinese ENGOs to gain legitimacy and political leverage without entering into open conflict with the authorities. Through strategies such as voluntary co-option and embedding themselves within the state apparatus, ENGOs manage to cultivate a cooperative relationship with government entities, thus maintaining a balance between achieving their environmental goals and navigating the state's power structures (Ho, 2001; Ho & Edmonds, 2008; Sullivan & Xie, 2009; Teets, 2014; J. Xu & Byrne, 2021; Yuen, 2018). Beyond the environmental activism domain, the broader general public also exhibits significant trust in — and reliance on — the state's ability to address environmental problems (Wong, 2010). This trust is accompanied by a noticeable hesitancy within the public discourse to engage with the political dimensions of climate change. For instance, Lo (2015) finds that climate discussions among young and educated Chinese are marked by political ambiguity as they rarely touch upon the significant influence political structures and forces have on climate change, even though there is a consensus on the urgency of addressing climate change (Lo, 2015, p. 770).

The depoliticization and the resulting politically disengaged discourse of climate change has significant consequences. Political disengagement leads to a limited willingness — and capability— to question political institutions' role in both the exacerbation and mitigation of climate change. Instead of encouraging critical public dialogues, this is likely to produce a

passive acceptance of policy decisions and marginalize critical voices that call for systemic change. Such an overreliance on government to initiate climate actions hinders the development of an informed, engaged climate citizenry capable of challenging the status quo. The lack of a politically active civil society, in turn, is likely to perpetuate the situation where the responsibility for climate action is largely deferred to the government, and thus limiting the potential for alternative approaches to sustainability and effectiveness and inclusivity of China's response to climate change.

Furthermore, a depoliticized climate discourse sidelines the debates necessary for understanding the deeper causes of environmental problems embedded in our social, political, and economic systems. It dismisses the critical reflection on the way in which political-economic systems contribute to the climate dilemma, thereby preserving the existing macro-level power structures that led us into the climate dilemma in the first place. This narrows the range of imaginable climate solutions to those compatible with current political and economic ideologies, sidelining more radical, albeit necessary, approaches to comprehensively address the scale and complexity of climate change. The consequence is not trivial. When we focus solely on adjustments that fit within established frameworks, without questioning or aiming to reform these frameworks, we delay the progress towards genuinely transformative climate solutions and makes it harder to tackle the climate crisis effectively and inclusively.

In terms of the way forward, addressing the depoliticization of climate change and fostering a politically engaged citizenship in China requires strategic engagement that is sensitive to the socio-political context while finding innovative ways to introduce and expand political engagement within environmental discourse. This entails a careful balance between collaboration and critique. To cultivate an empowered citizenry capable of critical engagement with climate

change, more efforts should be made to foster a more diverse and inclusive range of voices in climate change discourse, particularly those that can question and challenge the status quo and offer alternative perspectives of our future imaginary. As argued throughout this dissertation, digitally networked climate communication and participation can offer substantial opportunities to foster a more diverse and inclusive range of voices in climate change discourse and cultivate an informed, engaged, and critical climate citizenry.

Through leveraging networks of individuals, ideas, and the interactions between them, even casual online expressions about climate change in people's daily use of social media can be transformed into avenues for substantial impact. This is built on the idea that communication is more than a matter of transmitting predefined information, but a constitutive practice that builds our political subjectivity, as Carvalho et al. (2017) have articulated. Many scholars have highlighted the importance of everyday conversations on public and political issues in developing individuals' social agency and enacting their citizenship (e.g., Dahlgren, 2005, 2009; Habermas, 1985; J. Kim & Kim, 2008; Mansbridge, 1999). The personal concerns voiced by individuals often mirror larger societal issues. When these personal concerns are expressed online and shared through online social networks, they are likely to find resonance with the broader public and thus create a bridge between private lives and the public domain (Graham, Jackson, & Wright, 2015). Connectedness in the network structure offers great potential to aggregate and scale up micro expressions in the critical debate about the socio-political changes needed in addressing climate change and thus helping to move public conversations beyond depoliticization towards a more holistic view of sustainability. As such, online expressions on public issues are not trivial but pivotal in cultivating a shared understanding and equipping individuals for socio-political engagement.

This form of being political may be highly informal, occasional, and even populist (Boyte, 2005), and therefore might not conform to normative frameworks of deliberative and rational debate-based participation. Nevertheless, compared with formalized and institutionalized modes of participation, individualistic expressive participation can be more accessible, inclusive, and better reflect grassroots concerns as the participation motivation stems from people's everyday life experiences. In this context, the informality, spontaneousness, and interconnectedness of digitally networked communication are, nevertheless, instrumental in helping individuals to build their environmental identity through seemingly trivial online activities. Seen through this lens, individuals' online expressions and discussions about climate change in digital communication networks are not merely personal conversations but acts of citizenship that contribute to a collective shaping of responses to the global challenge of climate change.

This dissertation has illuminated the dual nature of digital communication networks, highlighting their potential to both facilitate and limit public discourse and participation in environmental issues within China. As we move forward, fostering more proactive public engagement that is both effective and sensitive to the landscape of environmental governance in China calls for continued research into the nuances and development of the Chinese climate discourse, the role of digital platforms' technological affordances and cultural environments in shaping online interactions, and the dynamics in the broader environmental governance and movement contexts in China. Research into the interplay between technology, society, and politics in these ecosystems will not only enrich our theoretical understanding of how digitally networked climate communication and participation can be leveraged to foster a more informed, engaged, and resilient environmental citizenship, but also offers insights for activist, policymakers, and various stakeholders with practical approaches in their endeavors in

addressing climate change. The journey may be complex, but the rewards — a more sustainable, resilient, and environmentally conscious civil society — are profound and far-reaching.

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Zinda, J. A., Li, Y., & Liu, J. C.-E. (2018b). China's summons for environmental sociology. *Current Sociology*, *66*(6), 867–885. https://doi.org/10.1177/0011392118778098

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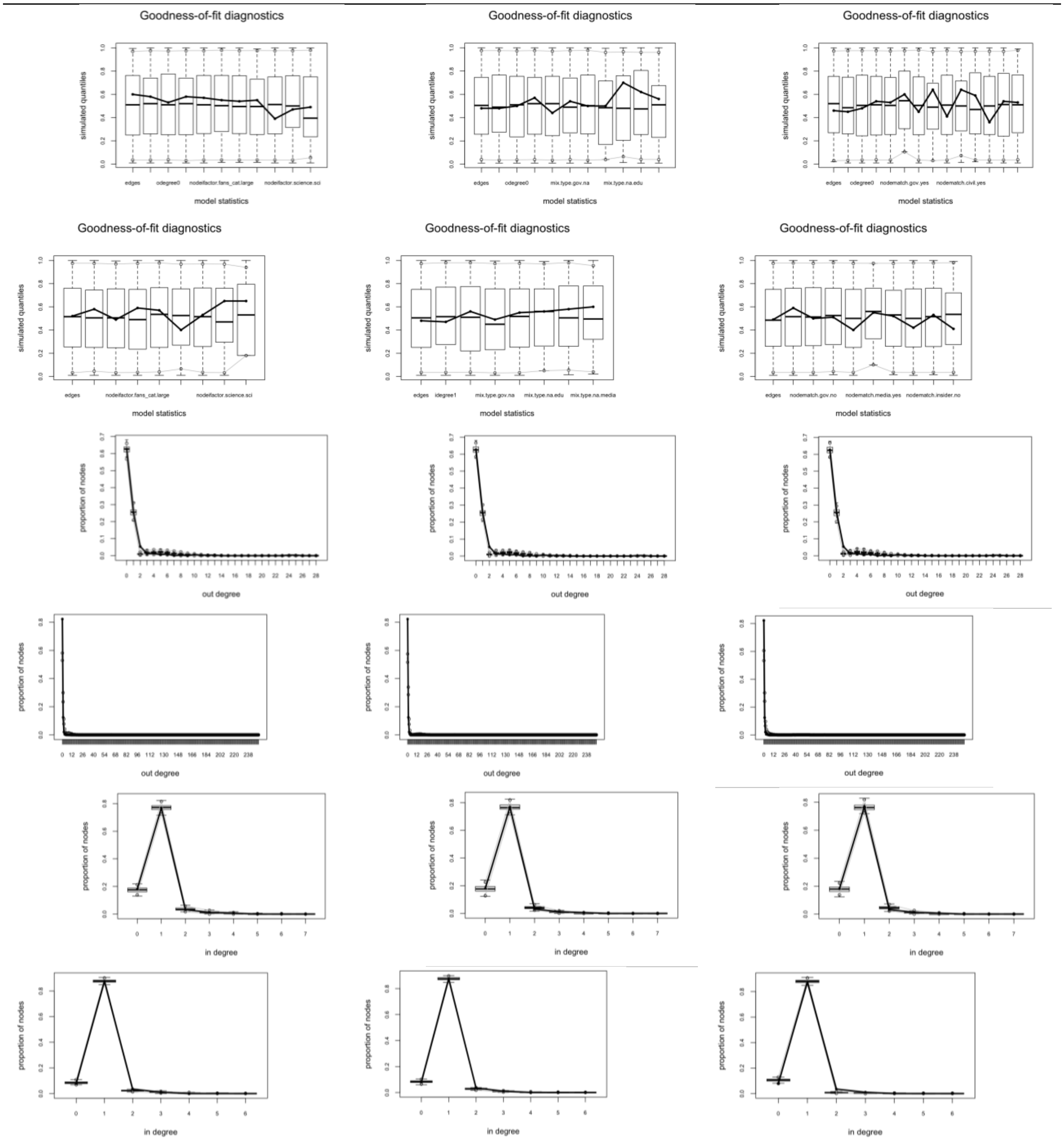
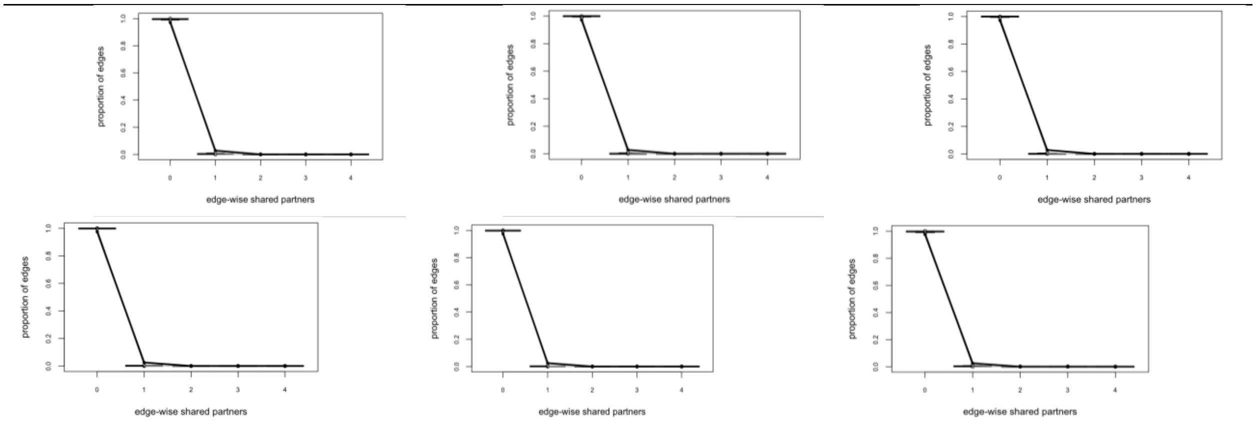
Appendices

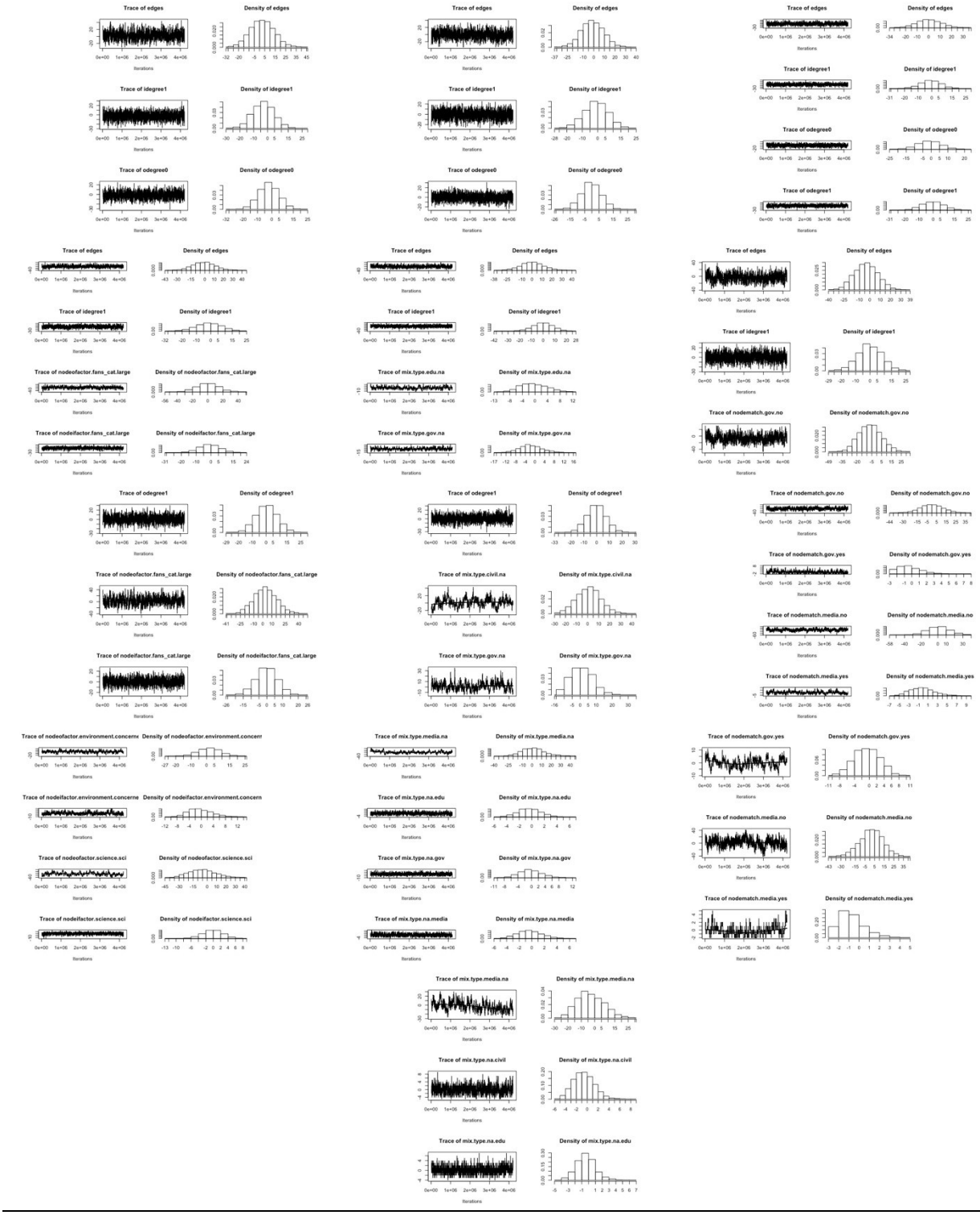
Appendix 1

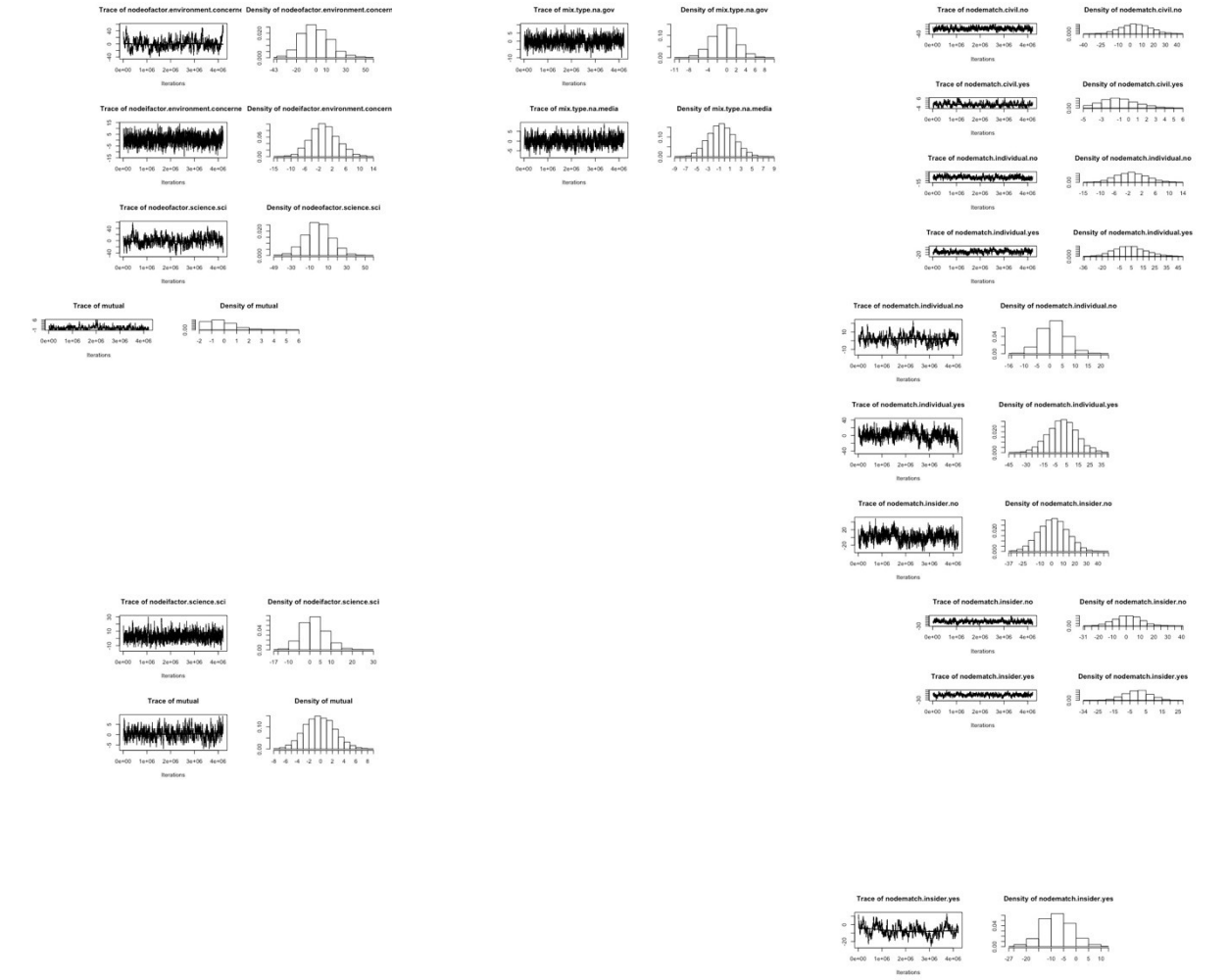
ERGMs goodness-of-fit (GOF) and Convergence statistics.

Model 1		Model 2		Model 3	
AR5	SR15	AR5	SR15	AR5	SR15




proportion of edges
edge-wise shared partners
proportion of edges
edge-wise shared partners
proportion of edges
edge-wise shared partners
proportion of edges
edge-wise shared partners
proportion of edges
edge-wise shared partners
proportion of edges
edge-wise shared partners


Trace of edges
Density of edges
Trace of idegree1
Density of idegree1
Trace of odegree0
Density of odegree0
Trace of odegree1
Density of odegree1
Trace of nodeofactor.fans_cat.large
Density of nodeofactor.fans_cat.large
Trace of nodeifactor.fans_cat.large
Density of nodeifactor.fans_cat.large
Trace of mix.type.edu.na
Density of mix.type.edu.na
Trace of mix.type.gov.na
Density of mix.type.gov.na
Trace of nodematch.gov.no
Density of nodematch.gov.no
Trace of nodematch.gov.yes
Density of nodematch.gov.yes
Trace of nodematch.media.no
Density of nodematch.media.no
Trace of nodematch.media.yes
Density of nodematch.media.yes
Trace of mix.type.civil.na
Density of mix.type.civil.na
Trace of nodeofactor.environment.concern
Density of nodeofactor.environment.concern
Trace of nodeifactor.environment.concern
Density of nodeifactor.environment.concern
Trace of mix.type.media.na
Density of mix.type.media.na
Trace of mix.type.na.edu
Density of mix.type.na.edu
Trace of nodeofactor.science.sci
Density of nodeofactor.science.sci
Trace of nodeifactor.science.sci
Density of nodeifactor.science.sci
Trace of mix.type.na.gov
Density of mix.type.na.gov
Trace of mix.type.na.media
Density of mix.type.na.media
Trace of mix.type.na.civil
Density of mix.type.na.civil
Iterations



Appendix 2

Appendix 2-A Topic Group Internal Density and External Connection Rates

We examine the strength of group connectedness through calculating topic groups' average internal density and external connection rate over the years. We define a group's internal density

as the proportion of possible connections within this group that actually present. A group's external connection rate with another group is defined as the proportion of possible connections across the given two groups that exist.

Let N_a denote the number of topics in topic group *a* and I_t be the number of observed internal edges in this group in year *t*, then the internal density of the given group can be expressed as $D(t) = \frac{2I_t}{N_a(N_a-1)}$ and the yearly average internal density can be expressed as $\frac{1}{M}\sum_{t=t_0}^{M} D(t)$, where M is the number of years. The external connection rate of a topic group with another one is defined as the proportion of possible across group connections that are observed. The external connection rate of group *a* with group *b* in year *t* can be expressed as $R(t) = \frac{2E_t}{N_a N_b}$, where E_t denotes the observed edges across the two groups in year *t*; and the yearly average external connection is $\frac{\sum_{t=t0}^{M} R(t)}{M}$. We use groups' internal density and external connection rate as indicators to the strength of their connectedness in topic networks. A group with a higher internal density represents a more cohesive theme in public discourse whereas a group with a higher external connection rate represents a more diffuse theme that is often closely associated with others in the public discourse. Figure Appendix2-A plots the internal density of the environmentalism and the development groups, as well as the connection rate across the two groups.

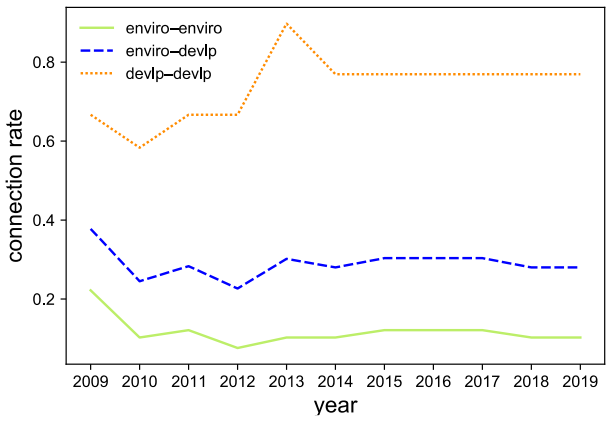


Figure Appendix2-A. Yearly internal density and external connection rate of the environmentalism and development groups.

Appendix 2-B Model Selection Tests Results

Figure Appendix2-B1 shows the test results for selecting the number of topics for analysis. Figure Appendix2-B2 illustrates topics' exclusivity (M. E. Roberts et al., 2014) and semantic coherence scores (Mimno, Wallach, Talley, Leenders, & McCallum, 2011) in our final model (K=56).

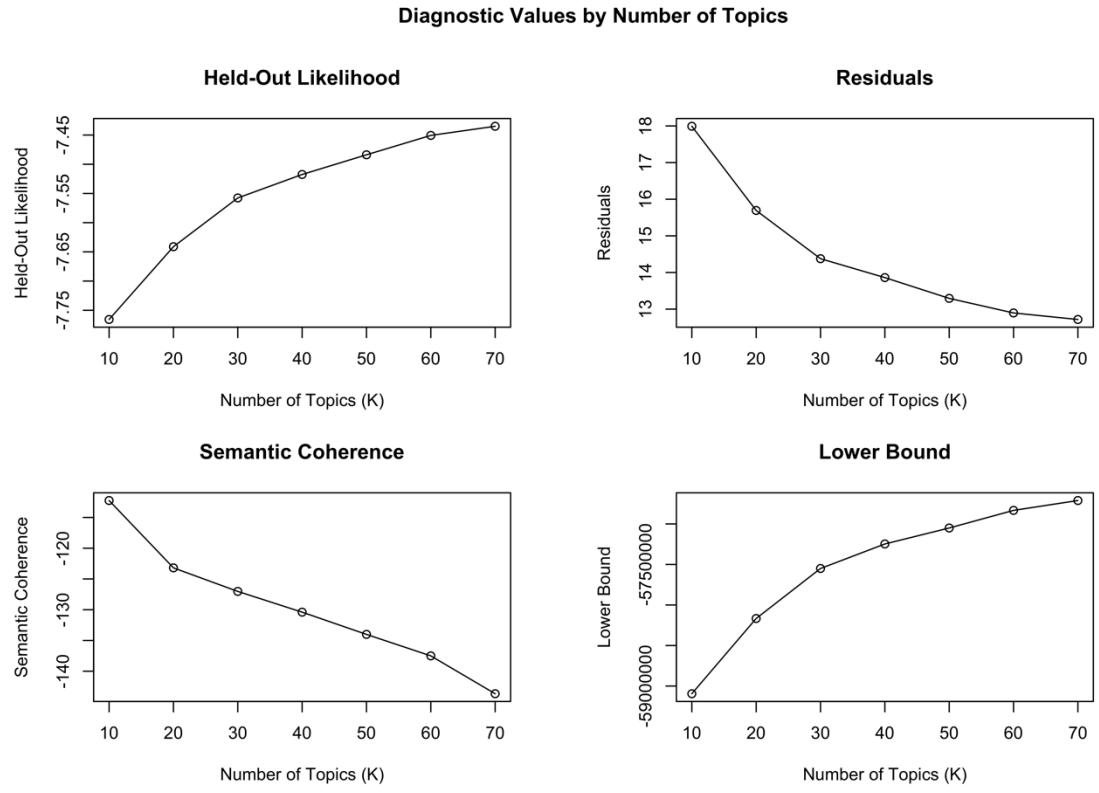


Figure Appendix2-B1. Results of test statistics for model selection, with *K* ranging from 10 to 70 in steps of 10.

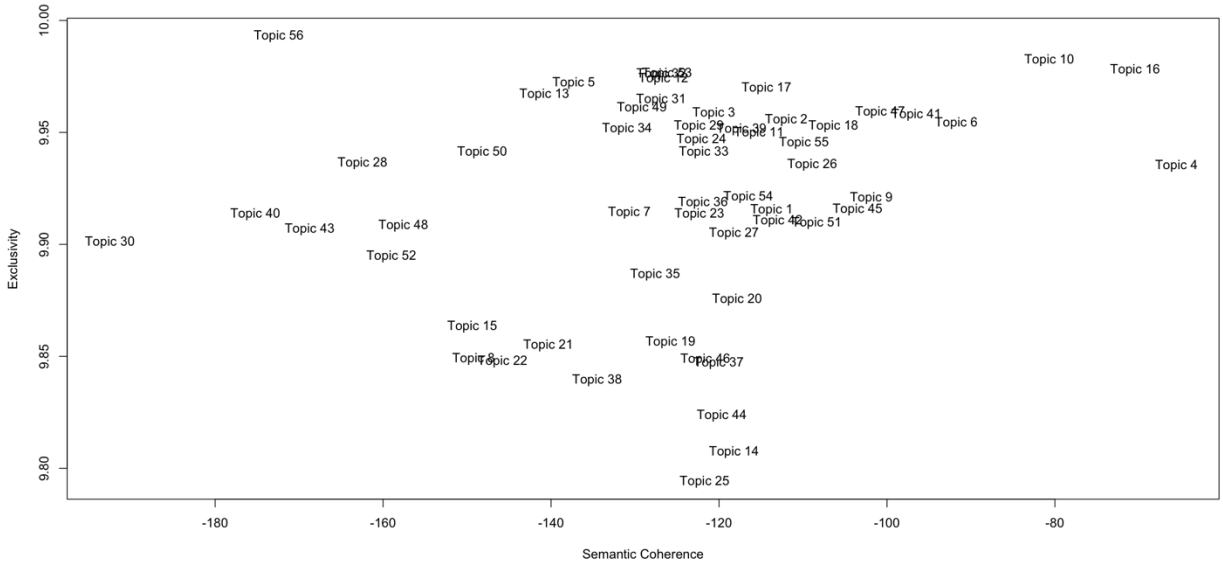


Figure Appendix2-B2. Semantic coherence and exclusivity scores of topics when *K* = 56

Appendix 2-C Top Words and Representative Post of Topics

Table Appendix2-C1 lists the original texts of topics' high probability words and example posts, along with a short description for each relevant topic.

Table Appendix2-C1. Major topics in climate change public discussion on Weibo.

Topic label	High probability words	Example posts	Description
temperature rise	全球, 气温, 上升, 变暖, 20, 10, 温度, 超过, 过去, 摄氏度	在 21 世纪，预测全球温度将上升 2 至 6 度，在过去的两百万年全球变暖的时期，大约 5000 年温度升高 5 度，而本世纪全球变暖的速度至少是当时的 20 倍，这是及其不寻常的。	Historical and projected future temperature rise due to human activities; temperature anomalies; rapid warming of the Arctic and Antarctica regions; hotter/colder-than-usual experience.
debate	说, 现在, 应该, 一直, 是否, 原因, 最近, 相信, 变冷, 告诉	专家一些说全球变暖~ 一些说全球变冷~ 专家你们说的话到底靠不靠谱的啦~	The public debate over whether the climate is changing due to human activities, including debates between climate skepticism and discussions about scientific evidence.
impact	影响, 会, 可能, 导致, 造成, 严重, 带来, 受, 加剧, 增加	【吃货们的噩耗！全球变暖 30 年后就吃不上巧克力了！】据美国海洋大气气候组织的专家预计，全球变暖在未来 30 年里会给可可产量带来严重打击，从而导致巧克力供不应求。可可是一种热带植物，对生长环境的要求非常高，尤其是充足的水分。而全球变暖导致的气温升高会让土壤和植物流失更多的水分，而降雨无法弥补这一损失。到了 2050 年，适宜可可生长的区域将被缩小至深山的原始丛林中。然而那里或早或晚会被划分为自然保护区，无法种植商业作物。如果环境问题没有改善，说不定甜食党的末日真的会到来。 全球头条新闻 大爆料的秒拍视频	Climate change's impacts on human society, including ecological, economic, social and other aspects.
climate campaign	环保, 一起, 保护, 关注, 绿色, 行动, 保护环境, 家园, 公益, 呼吁	@世青创新中心 #世青气候行动# 作为一名保护气候的志愿者，我郑重承诺：尽量不使用一次性餐具，节约用水，节约纸张，随手关灯，低碳出行，时刻关注气候变化，尽自己所能呼吁大家保护环境，让我们共同努力，一起为地球母亲作出自己的贡献。	Pro-environmental campaigns that call for individual behaviour changes in everyday life. A large part of this topic is about youth participation in climate change actions, international climate conferences, and youth-organized NGO activities.

research	研究, 科学家, 发表, 发现, 博文, 新, 英国, 报道, 认为, 称	发表了一篇转载博文 《[转载]科学家为全球变暖“暂停”找到两种解释》/ 科学家揭示全球变暖并未停滞—论文—科学网 科学家揭示全球变暖并未停滞	Recent scientific and technological advances on climate change, its impacts, and mitigation and adaption
US	美国, 特朗普, 总统, 退出, 奥巴马, 宣布, 表示, 政府, 报道, 加拿大	抗议气候变化， 81 岁奥斯卡影后简·方达在美国会前被捕¡¿【文/观察者网 赵挪亚】又有示威者因为抗议气候变化在美国被捕，这次是奥斯卡影后，81 岁的好莱坞著名女演员简·方达。据《纽约时报》10 月 11 日报道，华盛顿警方当天在国会大厦外，以“聚众、阻碍或妨碍”的罪名逮捕了包括方达在内的 16 名抗议气候变化问题的示威者。 抗议气候变化， 81 岁奥斯卡影后简·方达在美国会前被捕	Mainly about US-related climate affairs, including both governmental and civic actions. A large part of this topic is about the US withdrawal from the Paris Agreement.
earth hour	小时, 地球, 自然, 全球, 世界, 基金会, 活动, 熄灯, 一个, 行动	“关掉灯光，点起烛光”地球 🌐 一小时烛光晚餐主题活动，我为地球关灯一小时。（地球一小时（Earth Hour）是世界自然基金会（WWF）应对全球气候变化所提出的一项全球性节能活动，提倡于每年三月的最后一个星期六当地时间晚上 20:30，家庭及商界用户关上不必要的电灯及耗电产品一小时，以此来表明他们对应对气候变化行动的支持。）	The Earth Hour campaigns
imaginaries	地球, 生命, 灾难, 变成, 拯救, 会, 阻止, 时间, 人类, 发生	【描绘全球变暖带给地球致命灾难的科幻色彩纪录片—《愚昧年代》】这部混合纪录、动画、戏剧、科幻等元素的纪录片，通过一位年迈的档案保管员的视角，讲述了这位生活在的已被摧毁的未来世界中的老人，翻看公元 2015 年以前影像资料的悲哀和悔恨。[恐怖]	Depictions about our future under the threat of climate change. Many of them discuss disaster-themed fictional films, documentaries, and artwork.
extreme weather	天气, 极端, 出现, 气候, 高温, 事件, 现象, 发生, 地区, 今年	【数说厄尔尼诺：全球变暖背景下厄尔尼诺事件增多了么？】入冬以来，我国南方地区出现罕见持续阴雨天气，究其原因与厄尔尼诺不无关系。根据气候监测，自 2018 年 9 月以来，赤道中东太平洋海温持续偏高，进入厄尔尼诺状态，有利于冬季西太平洋副热带高压偏强偏西且稳定维持，加上南支槽阶段性活跃，引导了大量低纬度的水汽向我国南方地区输送；同时，入冬以来冷空气活动多，且势力较强，冷暖空气频繁在南方地区交汇，因而导致我国南方地区出现罕见的持续阴雨寡照天气。那么，随着全球变暖，厄尔尼诺事件有什么变化么？发生频率是增多了还是减少了	Discussions about weather anomalies within China and at the global scale. E.g., El Niño and La Niña, droughts in the northern and floods in the southern part of China, and extreme cold or hot days.

		呢？@中国天气数说厄尔尼诺：全球变暖背景下厄尔尼诺事件增多了么？	
polar regions	北极熊, 北极, 融化, 南极, 冰川融化, 冰, 企鹅, 海冰, 极地, 冰盖	【海冰消融 北极熊饿死像“一张平铺的毛毯”】北极熊专家伊恩-斯特林在北冰洋区域发现一头被饿死的北极熊，骨瘦如柴，令人不敢直视，它在搜寻海豹的绝望之旅中活活饿死。他分析，气候变化已使海冰面积降至历史最低，为寻找食物，北极熊不得不越走越远。via 环球网	Climate change’s impacts on the Arctic and Antarctica regions. Often involves images of skinny polar bears, melting sea ice, and wildlife habitat loss.
effect	气候, 变化, 影响, 地区, 不同, 形成, 因素, 主要, 过程, 植物	#物种日历# 才不是什么“草原害鼠”，我是兔兔！北美鼠兔虽看上去像是萌萌的小鼠，但其实和兔子的关系更近。在预测气候变化方面，北美鼠兔是最有代表性和指示性的物种之一。它们非常怕热，只在凉爽潮湿的岩石环境里繁衍。然而，气候变暖，正在让适宜它们生存的栖息地越来越少：网页链接	Climate change’s (long-term) ecological, geological, and meteorological effects.
UNFCCC	大会, 联合国, 会议, 12, 举行, 11, 召开, 气候大会, 代表, 巴黎	#世青气候行动#｛视频播报－ 联合国气候变化大会中国青年代表团 Day 1（12 月 3 日）]来啦！，来看看中国青年小伙伴们精彩而充实的第一天哦！打卡“中国角”，见证#联合国气候变化大会# 开幕式，天南海北的小伙伴们第一次面对面相见认亲哦 了解更多世青及 COP24 中国青年代表团，请点击 O 网页链接 #Youth4Climate 挑战赛#，与我们一起让青年人参与气候变化的学习、倡导和行动！ 世青创新中心的秒拍视频	International climate conferences and summits under the UN framework, including news reporting on UNFCCC COP meetings, high-level officials’ speeches and policy briefings, discussions about China’s role in international climate politics, and youth and celebrity participation in international climate events.
sustainable future	世界, 一个, 社会, 中, 时代, 新, 政治, 能够, 人民, 创造	马云：抗击疾病、贫穷、气候变化的第三次世界大战即将打响_cnBeta 人物 - 马云_cnBeta.COM 马云：抗击疾病、贫穷、气候变化的第三次世界大战即将打响	Future (positive) imaginaries that focus on ecological soundness, poverty elimination, and security.
awareness & action	问题, 环境, 生活, 关注, 改变, 解决, 方式, 健康, 面对, 带来	【HSBC 在游泳池底部贴了一张巨幅纽约空中俯视图，看起来像是纽约陷入了海底】水下纽约、英国汇丰银行做了一件有趣的事情，他们在游泳池底部贴了一张巨幅纽约空中俯视图，看起来像是纽约陷入了海底，以此提醒人们关注因气候变化而引起的海平面上升等问题。 网页链接	Raising public awareness and advocating greener lifestyles to protect the environment and address climate change.
economy	全球, 经济, 发展, 挑战, 成为, 增长, 面临, 世界, 未来, 人口	同时，国际金融危机深层次影响仍然存在，国际金融市场不稳定不确定因素增多，国际和地区热点此起彼伏，气候变化、生态恶化、能源资源安全、粮食安全、重大自然灾害等全球性挑战日益突出，全球金融治理任重道远。有效应对全球发展面临的挑	Climate change’s economic influences and financial risks/opportunities.

		战、实现共同发展已经成为国际社会普遍关注的重大课题。	
international agreement	气候, 联合国, 全球, 巴黎协定, 协议, 巴黎, 各国, 目标, 达成, 秘书长	气候变化《巴黎协定》今天正式生效 这份重要协定关乎你我 气候变化 《巴黎协定》今天正式生效 这份重要协定关乎你我	International protocols and agreements achieved under the UNFCCC framework or within the UN system. A large part of this topic is devoted to Paris Agreement, which is mostly discussed in a positive tone and praised as a historic milestone in global climate governance.
glacier & tourism	冰川, 米, 位于, 公园, 海拔, 美丽, 地方, 沙漠, 湖泊, 河流	【那些即将消失的风景】法国心形红树林，现在已经只能在胶片上找到当年的印迹，水位增高，树林已经被打散；一条蜿蜒在冰川上的碧绿的河流，形如绿蛇，大自然叹为观止的造物景观；力马扎罗山的雪，由于全球变暖，未来可能不复存在；泰国攀龙湾，以后最可能实际见证的地方。	Impacts and risks of climate change on glaciers, snow-capped mountains in China, and the natural-oriented tourism industry.
press	中国, 国家, 网, 北京, 记者, 中心, 副, 特别, 主任, 解振华	【专访潘基文：中国减贫事业为世界做出榜样】28 日，人民日报专访#博鳌亚洲论坛#理事长潘基文：①40 年改革开放给中国带来巨变；②中国减贫事业上作出了“世界榜样”；③应对气候变化，中国起了带头作用。借此机会，潘基文还向新中国成立 70 周年表示衷心祝福。戳视频↓↓（来源：人民日报）人民日报的秒拍视频	Media interviews, press briefings, and news reports about climate change and climate policies.
extinction	灭绝, 物种, 消失, 海平面上升, 动物, 澳大利亚, 珊瑚, 海水, 数量, 导致	#首个因气候变化灭绝的哺乳动物# 【澳大利亚官方确认珊瑚裸尾鼠灭绝，这是#首个因气候变化灭绝的哺乳动物#】2 月 18 日，珊瑚裸尾鼠灭绝已被澳大利亚官方确认，成首个因人为引起的气候变化灭绝的哺乳动物。海平面上升，栖息地出现极高水位和破坏性风暴潮频发，这些人为引起的气候变化是导致珊瑚裸尾鼠灭绝的根本原因。@时差视频 时差视频的秒拍视频	Extinct or endangered wildlife due to climate change.
international cooperation	国际, 合作, 共同, 论坛, 中美, 领域, 中, 峰会, 对话, 双方	【习近平会见萨摩亚总理】图伊拉埃帕表示，萨中建交 43 年来，两国在一个中国原则基础上发展起相互信任、友好的紧密关系。萨方珍视同中方关系，支持“一带一路”倡议，愿在这一重要框架内拓展两国在经贸、投资、旅游等领域合作，密切人文交流。萨方赞赏中方在应对气候变化方面的引领作用，愿加强双方在多边事务中合作。网页链接	China’s involvement in global climate actions, international collaborative relations on climate change, South-South cooperation through the Belt and Road Initiative etc.
green growth	发展, 绿色, 建设, 技术, 可持续发展, 推动, 创新, 实现, 推进, 促进	再生资源产业发展是生态文明建设的重要内容，是实现绿色发展的重要手段，也是应对气候变化、保障生态安全的重要途径。推动再生资源产业健	Discussions around the notion of ecological civilization, including sustainable development, green production and consumption,

		康持续发展，对转变发展方式，实现资源循环利用，将起到积极的促进作用。大力发展再生资源产业，对全面推进绿色制造、实现绿色增长、引导绿色消费也具有重要意义。	industrial upgrading, emission reduction and energy conservation, technological innovation and entrepreneurship.
low-carbon campaign	活动, 主题, 低碳, 了解, 宣传, 知识, 全国, 公众, 节能, 参与	官山社区：开展“节能降耗 保卫蓝天”节能宣传周活动　　2018 年 6 月 11 日至 17 日为第 28 个全国节能宣传周，6 月 13 日为第 5 个全国低碳日。今年全国节能宣传周活动的主题是“节能降耗保卫蓝天”，全国低碳日活动主题是“提升气候变化意识，强化低碳行动力度”。 为了深入开展节能宣传周活动，官山社区组织辖区内的党员志愿者、两型科普志愿者、社区居民开展节能宣传周活动。　　活动中，志愿者们走进社区，设立节能宣传栏，以节能降碳为重点，普及生态文明理念和节能低碳、节水、节电、节油、节粮和资源循环利用知识。另外官山社区走进大官山小学，开展节能宣传知识讲座，为同学们上演了一场别开生面的节能知识教育课，增强了同学们的节能意识。　　通过此次活动，营造了崇尚节俭、厉行节约的良好氛围，倡导简约适度、绿色低碳的工作和生活方式，进一步提高居民的节能责任意识。	Low carbon lifestyle and behaviour change, including state-led campaigns, UN-led events, NGOs-led activities, and international events such as Earth Day, Forest Day, etc.
business action	项目, 计划, 企业, 组织, 公司, 投资, 提供, 机构, 支持, 获得	【广州 BRT 被评为联合国“2012 年应对气候变化灯塔项目”】近日，广州 BRT 项目被联合国气候变化顾问委员会评为“2012 年应对气候变化灯塔项目”。这是广州 BRT 继“可持续交通奖”后获得的又一个世界级奖项。广州 BRT 的单向客流量是亚洲其他 BRT 的三倍以上，在世界上仅次于哥伦比亚波哥大网页链接	Business companies’ climate actions, practices of sustainable production, and other business-related contributions to climate mitigation and adaptation.
crisis	人类, 威胁, 正在, 生存, 已经, 危机, 未来, 面临, 警告, 正	【霍金再发警告：人类处于最危险时期 必须要“重新再教育”】英国著名物理学家史蒂芬-霍金近日在《卫报》再发警告性文章称，我们目前正生活于人类历史上最危险的时期，人口过剩、气候变化、流行病等都是人类将要面临的严重威胁。霍金表示，我们所发展的科学技术将可能毁灭我们的地球。在一个机器人可以替代人类完成大多数工作的新世界里，人类必须要“重新再教育”。霍金发警告:人类处最危险时期	Ecological crisis in the short- and long-term future at the global scale.
CO_2 reduction	排放, 减少, 温室气体, 二氧化碳,	#蓝天保卫战我是行动者# 甲烷既是空气污染物，又是强效温室气体。它的暖化效应是二氧化碳的 80 倍。石	Reducing greenhouse gas emissions in areas ranging from individuals’ everyday life to national industrial transformation.

	碳, 排放量, 控制, 降低, 中, 使用	油和天然气行业是最大的工业甲烷排放源，其中大部分排放来自泄漏，可使用特殊的热像仪进行检测。 严防甲烷泄漏、严控各种形式的甲烷排放是快速应对气候变化以及对抗空气污染的有效方法 #世界环境日# 联合国环境规划署的秒拍视频	
scientist	科学, 研究, 中心, 教授, 大学, 科技, 学院, 专家, 环境, 专业	解读#2018 诺贝尔奖# 2018 年诺贝尔经济学奖授予:William D. Nordhaus 和 Paul M. Romer 以表彰他们将“气候变化与技术创新纳入长期的宏观经济学分析”气候变化与技术创新，2018 诺贝尔经济学奖揭晓!	Scientists and recent scientific advances in climate science, meteorology, and other environment-related fields.
smog	报告, 发布, 气象, 雾霾, 气候, 影响, 委员会, 评估, 政府, 间	【气候变化绿皮书称雾霾会影响生殖能力】中国社科院、中国气象局昨天发布《气候变化绿皮书》，指出我国霾日数明显增加，且持续性霾过程增加显著。报告称雾霾天气影响健康，使慢性病加剧、呼吸及心脏系统疾病恶化，肺功能及结构改变、影响生殖能力、改变人体免疫结构、增加死亡率等视频：气候变化绿皮书称雾霾会影响生殖能力	Smog and air pollution.
energy	能源, 英国, 再生能源, 太阳能, 清洁能源, 煤炭, 新能源, 石油, 发电, 汽车	#全球能源互联网专题# 总体来看，各研究机构对未来人类应对气候变化的决心已经形成共识，但对应对气候变化发展进程的认识有所不同。根据 IPCC 的报告，要满足到 2050 年大气温升控制在 2℃以内的目标要求，世界各国实施清洁能源替代、电能替代的力度需要进一步加大，可再生能源开发利用规模和占比要更高，才能更好地实现人类社会可持续发展目标。为实现这一目标，“一极一道”及各大洲大型可再生能源基地应加快开发进程、提高开发规模，将全球大型可再生能源基地纳入全球范围配置。（图片来源于网络）	Clean and renewable energy developments, including policies, production and consumption, and energy conservation.
CO_2 trading	碳, 碳排放, 市场, 目标, 欧盟, 全国, 发改委, 我国, 规划, 交易	#智库财讯# 【全国碳排放交易市场望明年启动 千亿盛宴开启】国家发改委应对气候变化司副司长蒋兆理表示，全国碳排放交易市场启动已经进入倒计时，2016 年将加快抓紧制定各项配套细则和标准，确保明年全国碳排放交易市场启动运行。	The development of the national carbon trading scheme and related carbon market information and policies.
energy conservation and emission reduction	应对, 减排, 节能, 工作, 行动, 政策, 积极, 方案, 低碳发展, 改革	国家林业局办公室关于印发《2015 年林业应对气候变化政策与行动白皮书》的通知各省、自治区、直辖市林业厅（局），内蒙古、吉林、龙江、大兴安岭森工（林业）集团公司，新疆生产建设兵团林业局，国家林业局各司局、各直属单位: 2015	The state-led nationwide Energy Conservation and Emission Reduction action project, including related policies, Five-Year-Plans targets, volunteer actions from businesses and industries, local campaigns etc.

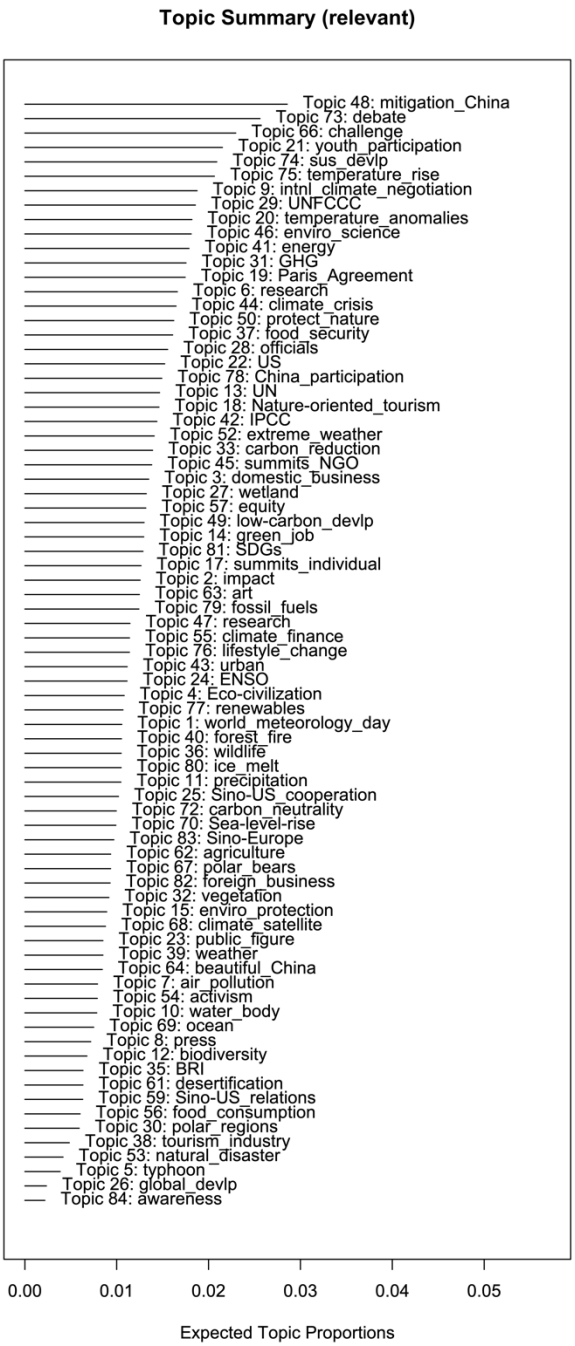
		年，按照国家应对气候变化工作统一部署，围绕《“十二五”控制温室气体排放工作方案》和《林业应对气候变化“十二五”行动要点》确定的目标任务，林业应对气候变化工作稳步扎实推进，各项工作取得了新进展。为全面反映 2015 年林业应对气候变化工作行动与成效，我局组织编制了《2015 年林业应对气候变化政策与行动白皮书》（见附件），现印发给你们，供参考。　　来源：国家林业局网站　　网页链接	
food	吃, 食物, 粮食, 少, 种植, 生产, 垃圾, 食品, 塑料, 肉	明白人越来越多。2 篇科学论文告诉“非盈利非政府国际公益组织”，应该把什么人当成宣传低碳环保饮食的对象。1，Journal of Industrial Ecology 统计发现，美国白人的饮食和方式最不环保！他们比黑人、拉丁裔美国人对气候变化的影响都大。白人饮食耗费的水相对最多，排放的温室气体也最多。仅牛奶一项，白人就比黑人对环境的影响大 35%以上！当然他们都比中国人更不环保，生活方式更不可持续。图 1、2，美国人均碳排放是中国人的 2-3 倍，白人人均更高。网页链接 2，Environmental Science & Technology 研究发现，食用动物内脏下水有助于显著减少碳排放。从头吃到尾（Nose-to-tail）的食肉方式应该被鼓励推广，可有效减缓肉类消费对气候变化的影响。同时，作者还建议转而食用碳排放更少的肉类，如猪肉和鸡肉。这样，即使到了 2020 年人均肉类消费达到 65.8kg，情况也会好许多。网页链接在吃肉与碳减排上，中国显然不是碳排放重灾区，中国人的饮食比较符合两篇科学论文的倡议。一，中国人的饮食方式对环境更友好，植食性食物为主，对水和土地的利用率更高。二，中国人吃的更多是猪肉和鸡肉，而不是碳排放最多的牛肉、羊肉。三，中国人吃各种动物下水，而且“从头吃到尾，Nose-to-tail”，而不是像美国人和欧洲人即使吃鸡，也把能吃的扔掉一大堆。触目惊心的数字，来自英国《每日邮报》和联合国粮农组织：全球每年约有 2.9 万亿磅粮食损失浪费（相当于世界粮食总产量 1/3）。在发达国家，浪费的食物相当于 6800 亿美元，发展中国家这一数字只有其一半不到。欧洲和北美每年人均浪费食物 95-115 千克，即 209-254 磅。这些被浪费的	Climate change’s impacts on food security, agriculture, aquaculture, and animal husbandry industries from local to global scales. This topic also includes discussions about vegan or vegetarian diets and debates over China’s meat and dairy consumption.

		食物本可以多养活数亿人。网页链接客观与科学最重要。如果 WILDAID 等所谓非盈利非政府国际公益组织的宗旨，真·像官方网站宣传的，是为了减少碳排放，呼吁“为地球减负”，那么似乎应该尊重科学，去鼓励世人尽量少吃牛肉，吃肉的话就多吃猪肉和鸡肉，就像中国人做的那样；多吃猪下水、鸡下水等等，学习中国人爆炒大肠、羊肚、猪肚、羊腰、猪腰、鸡胗、鸭胗、鸡肝、鸭肝等烹饪技法。此外，公益事业本应该敢于去最需要进步的地方推广发挥，这是真·公益的题中应有之义。科学界已经指出了方向：美国，白人群体（POPULAR SCIENCE 直白之处：“White Americans' diets are particularly bad for the planet！”）。建议公益大使仍然沿用为促减排出力站台的黄轩、张钧甯、郑恺、Angelababy、黄磊、李冰冰等人。他们的笑容在城市大小角落温暖我们两年了。“让美国和地球跟上健康的节奏。”→_→	
international negotiation	谈判, 承诺, 发展中国家, 发达国家, 德班, 京都议定书, 责任, 南非, 会议, 哥本哈根	【解振华怒了！】在南非德班联合国气候变化今天凌晨的最后一次全体大会上，中国代表团团长解振华在即席发言中，强烈批评西方国家拒不履行已做出的各项承诺。“我们要保护环境，该做的我们都做了，我们已经做了，你们还没有做到，你有什么资格在这里讲这些道理给我？！”网页链接 @News 上海	Discussions about international climate events, which often focus on disputes or conflicts in international climate negotiations, the North-South divide, developed countries' carbon debts and responsibilities on Green Climate Funds etc.
technology	数据, 系统, 卫星, 技术, 监测, 观测, 进行, 我国, 利用, 全球	【瞄准超算皇冠：神威 E 级超算原型机正式启用】运算速度达每秒百亿亿次的 E 级计算机，被称作“超级计算机界的下一顶皇冠”。8 月 5 日，国产超算研制向着这一皇冠又迈进了一步：神威 E 级超算原型机在国家超级计算济南中心完成部署，并正式启用。这一原型机系统，主要由硬件、软件和应用三大系统组成。其处理器、网络芯片组、存储和管理系统等核心器件全部为国产化。截至目前，神威 E 级超算原型机已完成包括全球气候变化、海洋数值模拟、生物医药仿真、大数据处理和类脑智能等 12 个领域的 35 项重大计算任务，未来应用前景非常广阔。	Cutting-edge technologies that help to monitor, model, and address climate change.
ecosystem	海洋, 生物, 保护, 森林, 重要, 生态系统, 多样性, 湿地, 作用, 中	#随手拍#这次愉快的青岛之行让我认识了“浒苔” 由于全球气候变化、水体富营养化等原因，造成海洋大型海藻浒苔绿潮暴发。大量浒苔漂浮聚集到	Climate change's impacts on biodiversity and ecosystem. It also contains calls for actions to protect the earth, oceans, forests, wetlands, and wildlife.

		岸边，阻塞航道，同时破坏海洋生态系统，严重威胁沿海渔业、旅游业发展。 秒拍视频（下载秒拍 APP 网页链接）	
urban	城市, 建筑, 设计, 上海, 深圳, 成都, 伦敦, 天津, 未来, 荷兰	【#全球数十座城市正在下沉# 学界警告部分城市或“整体消失”】印度尼西亚正式宣布将在 2024 年“迁都”，该国现在的首都雅加达已是“危城”一座，平均年沉降 25 厘米，位居全球之首。学界警告称，在未来数十年间，全球恐将有数十座主要城市或部分下沉、或“整体消失”，这一现象与气候变化、冰川融化	Rising sea levels, coastal erosion, and risks of coastal cities submerging. Also include discussions about sustainable urban planning and urban lifestyle changes.
EPBs	生态, 农业, 污染, 生态环境, 资源, 水, 土地, 水资源, 管理, 环境保护	【你好，北碚区生态环境局！】@重庆生态环境 今日，北碚区生态环境局正式挂牌亮相，北碚区副区长刘小辉出席挂牌仪式并为区生态环境局揭牌。根据《重庆市北碚区机构改革方案》，将区环境保护局的职责，以及区发展和改革委员会的应对气候变化和减排职责，区水利局的编制水功能区划、排污口设置管理、流域水环境保护职责，区国土资源管理分局的监督防止地下水污染职责，区农业委员会的监督指导农业面源污染治理职责等整合，组建区生态环境局，作为区政府工作部门，实行以市生态环境局为主的双重管理体制。不再保留区环境保护局。	Local environmental protection bureaus and institutions. Discussions about environmental governance to address ecological degradation issues such as pasture degradation, Yellow River basin floods and drought, water body pollution, and threats to wildlife habitat.
responsibility	需要, 必须, 努力, 采取, 措施, 帮助, 做出, 应, 全世界, 遏制	【习近平谈气候变化：任何一国都无法置身事外】 中国已经做出了表率，希望这次气候大会没人拖后腿 习近平谈气候变化：都无法置身事外	The responsibility of China and other countries to climate change mitigation and adaptation. In addition to the notion of common but differentiated responsibilities, this topic also includes discussions about business companies and individuals’ responsibilities.
Hong Kong, Taiwan, & overseas	氣候, 變化, 香港, 全球, 澳洲, 對, 台湾, 於, 為, 變暖	全球氣候變化帶來的危機迫在眉睫，天文台與香港電台聯合製作電台節目《大氣候》，探討與氣候變化有關的議題。第一集邀請到天文台台長親身講述香港風災史，與觀眾回顧過去為香港帶來嚴重破壞及人命傷亡的颱風。	Discussions about climate change in relation to Hong Kong, Taiwan and overseas Chinese.

Appendix 3

Appendix 3-A Topic modeling results



label	t o p ic	keyword

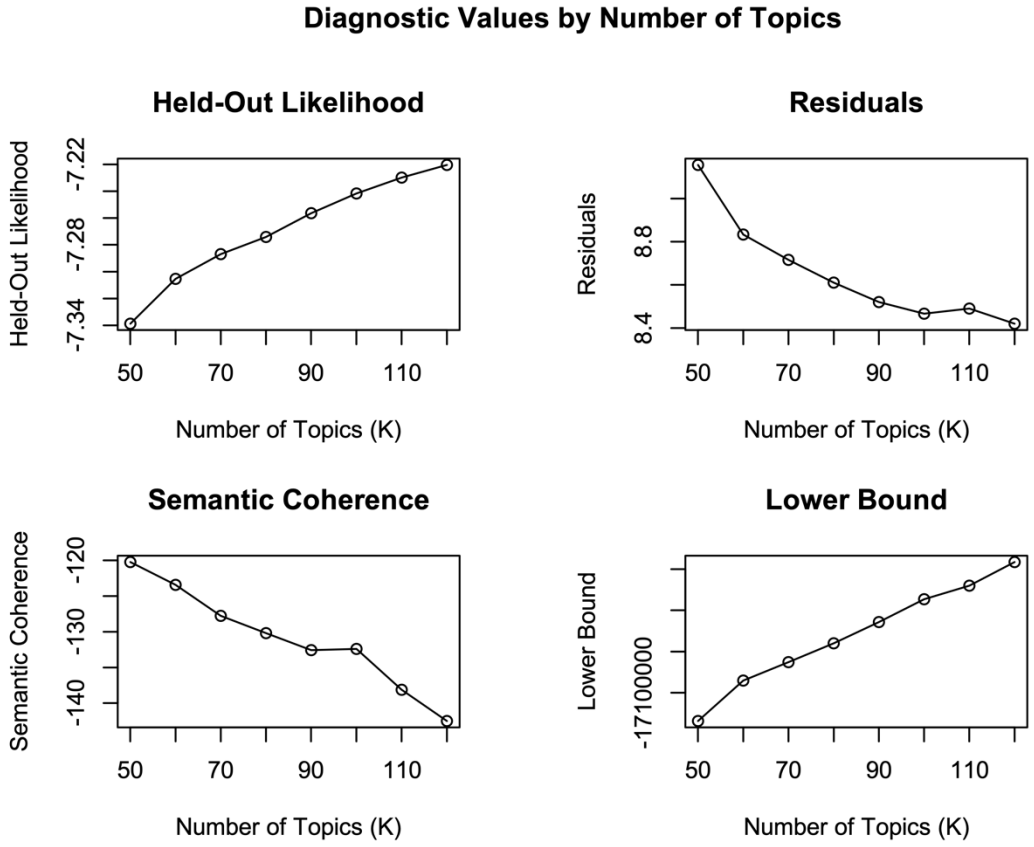
impact	1	prob 影响,造成,带来,导致,增加,产生,因素,受,严重,不断 frex 造成,影响,带来,因素,受,导致,不断,加剧,产生,后果 lift 造成,难以预测,负面影响,更为严重,啤酒,影响,因素,后果,不良影响,带来 score 影响,造成,导致,加剧,带来,增加,受,严重,因素,人类活动
/2	2	prob 一个,说,已经,需要,没有,现在,做,希望,很多,应该 frex 一个,现在,说,很多,非常,没有,需要,已经,告诉,不能 lift 事情,一个,毫无疑问,告诉,非常,发现自己,相信,很多,提及,事实上 score 一个,没有,说,现在,做,需要,应该,很多,不能,知道
hi-tech	3	prob 火星,号,nasa,地球,太空,中,飞机,气候,人工智能,使用 frex 太空,飞行,火星,月球,人工智能,机器人,nasa,探测器,行星,空间站 lift dscovr,epic,机器人,空间站,观测台,外行星,深空,火星车,量子,飞行器 score 火星,nasa,太空,探测器,飞行,人工智能,发射,行星,月球,飞机
China action	4	prob 中国,表示,大国,中国政府,方面,国际,角,专访,担当,第一 frex 中国,中国政府,角,担当,大国,专访,彰显,决心,展现,视点 lift 六朝,中国,中国政府,百分之百,角,彰显,专访,担当,坎贝尔,场边 score 中国,角,中国政府,大国,担当,专访,决心,彰显,展现,贡献者
research	5	prob 研究,中科院,植物,土壤,中,重要,进展,揭示,生态系统,气候 frex 中科院,中获,植物园,演化,微生物,同位素,揭示,植物所,古,世 lift 中获,中新世,二叠纪,分异,土壤有机,始新世,年代学,树轮,石笋,碳酸盐 score 中科院,研究,植物,土壤,揭示,中获,植被,生态系统,植物园,演化
smog	6	prob 气候,厄尔尼诺,雾霾,我国,拉尼娜,冬季,中心,国家,扩散,大气污染 frex 雾霾,拉尼娜,厄尔尼诺,霾,扩散,气象条件,京津冀,大气污染,总站,今冬 lift 弱到,逆温,长静稳,中到,偏冷,多霾,对重,总站,汾渭,转差 score 拉尼娜,厄尔尼诺,雾霾,大气污染,气象条件,霾,扩散,冬季,总站,今冬
EPBs	7	prob 生态环境,环境,环保,局,丨,环境保护,汶上,山东,孤独,求单 frex 求单,威海,市中,济阳,齐河,督察,济州,钢城,绿梦,微山 lift 兖州,博济,微山,求单,济州,钢城,齐河,之钉,冒泡泡,嘉祥 score 生态环境,环保,环境,汶上,求单,钢城,市中,督察,齐河,济阳
green_campaign	8	prob 一起,保护,地球,行动,公益,家园,保护环境,守护,起来,共同 frex 郑爽,做起,一起,斑海豹,保护环境,人人有责,youth4clim,发声,爱护,谭松韵 lift 郑爽,一援,小爽,应援,王俊凯,theclimateconnect,谭松韵,做起,连结,斑海豹 score 一起,郑爽,谭松韵,公益,斑海豹,地球,家园,行动,保护,守护
climate_sci	9	prob 变化,大气,气候,青藏高原,影响,区域,温度,地区,显著,降水 frex 变化,气候系统,青藏高原,东亚,环流,区域气候,显著,季风,水循环,气溶胶 lift 冻土退化,多年冻土,振荡,涛动,对流层,边界层,三峡工程,季风区,变化,enso score 变化,青藏高原,大气,降水,环流,气溶胶,温度,气候系统,季风,揭示
challenge&response	10	prob 全球,挑战,成为,新,面临,治理,共同,重要,未来,正 frex 挑战,严峻,治理,全球,面临,全球性,成为,角色,紧迫,面对 lift 置身事外,昌华,挑战,黑暗面,关乎,细语,严峻,当今,紧迫,新格局 score 全球,挑战,治理,面临,各国,共同,成为,机遇,严峻,全球性
pop_sci	11	prob 研究,科学,发现,发表,新,一项,自然,文章,人员,表明 frex 文章,一篇,杂志,查看,研究,论文,表明,博文,头条,模型 lift 一篇,两篇,文章,院刊,natur,natureclimatechang,科学论文,学术期刊,刊载,bull score 研究,发表,文章,科学,发现,杂志,查看,人员,论文,自然
officials	12	prob 论坛,部长,出席,主席,代表,解振华,事务,召开,副,特别 frex 部长,黄润,出席,论坛,年会,事务,会见,国合,主席,第二届 lift 国合,彼得斯,阿奇姆,麦肯,来华访问,第十六届,索尔海姆,韩正同,麦肯纳,施泰纳 score 论坛,部长,解振华,出席,黄润,会见,事务,主席,致辞,特使
Paris_Agreement	13	prob 巴黎,协议,巴黎协定,气候大会,达成,2015,协定,各国,生效,12 frex 巴黎,协议,马拉喀什,达成,生效,协定,2015,巴黎协定,cop21,约束力 lift cop21,交存,朗德,马拉喀什,法比尤斯,cop22,巴黎,协议,约束力,生效 score 巴黎,协议,气候大会,巴黎协定,达成,协定,生效,马拉喀什,2015,约束力
GCF	14	prob 承诺,发展中国家,国家,资金,发达国家,支持,亿美元,基金,提供,融资 frex 资金,发达国家,发展中国家,融资,亿美元,基金,承诺,履行,小岛屿,兑现 lift gcf,注资,启动资金,资金,融资,加元,发达国家,筹集,出资,小岛屿 score 承诺,发展中国家,资金,发达国家,亿美元,融资,基金,兑现,援助,履行
press	15	prob 新闻,记者,发布会,媒体,介绍,发布,采访,接受,例行,时 frex 发布会,新闻,例行,记者,采访,回答,提问,司长,媒体,李高 lift 例行,httptcna6xbutuz,发布会,新闻,提问,刘友宾,答记者问,国新办,回答,实录 score 新闻,发布会,例行,记者,提问,答问,回答,司,司长,媒体
climate_satellite	16	prob 数据,卫星,观测,监测,我国,系统,预报,预测,风云,全球 frex 卫星,观测,风云,气象卫星,数值,数据,监测,星,三号,遥感 lift 首颗,发射成功,太原卫星发射中心,极轨,科学实验,观测网,组网,长征四号,气象卫星,颗卫星 score 卫星,观测,数据,监测,预报,发射,风云,气象卫星,遥感,我国
innovation	17	prob 项目,技术,创新,发展,利用,资源,科技,产业,领域,提供 frex 项目,创新,技术,推广,科技,示范,产业,先进,资助,高效 lift 小额,竹材,建议书,雄安,资源化,if,农林业,推广,用能,路灯 score 项目,技术,创新,产业,科技,资源,示范,产品,推广,利用
wildlife	18	prob 人类,地球,自然,生命,生存,大自然,星球,拯救,和谐,保护 frex 人类,海龟,人与自然,共生,大自然,和谐,拯救,彭于,晏,星球 lift 海龟,爱登堡,彭于,晏,君侯,呐喊,为本,人类,和平相处,索取 score 人类,地球,自然,海龟,生命,生存,大自然,人与自然,彭于,和谐
pollutions	19	prob 环境,问题,健康,解决,改善,污染,空气,空气污染,清洁,重视 frex 空气污染,解决,问题,健康,重视,环境,观察团,蓝思众享,改善,环境污染 lift 门户网,蓝思众享,空气污染,漓江,科普读物,如能,盒子,观察团,过早,重视 score 环境,问题,健康,空气污染,解决,清洁,污染,改善,空气,观察团

US	20	prob 美国,总统,特朗普,退出,拜登,政府,奥巴马,宣布,巴黎协定,时间 frex 特朗普,退出,奥巴马,拜登,白宫,华盛顿,美国,民主党,竞选,国会 lift 重新加入,tpp,入主,共和党,共和党人,巴拉克,毁约,epa,参议员,哈里斯 score 美国,特朗普,拜登,总统,退出,奥巴马,白宫,巴黎协定,法案,协定
extreme_weather	21	prob 记录,世界气象组织,今年,2019,热,美国,最高,山火,一年,历史 frex 最热,世界气象组织,山火,纪录,年份,创下,野火,记录,新高,热 lift 最热,最热年,创下,热年,烟雾,1850,最暖,noaa,录得,年份 score 世界气象组织,记录,最热,山火,高温,气温,纪录,年份,热,大火
activism	22	prob 日本,岁,韩国,莱昂纳多,瑞典,比尔盖茨,气候峰会,少女,核,盖茨 frex 莱昂纳多,比尔盖茨,盖茨,日本,贝里,微软,贝索斯,韩国,瑞典,通 lift leonardodicaprio,布隆,核污染,比尔盖茨,盖茨,莱昂纳多,billgat,亿万富翁,格雷塔,迪卡 score 日本,莱昂纳多,比尔盖茨,盖茨,瑞典,伯格,贝里,韩国,贝索斯,微软
forest	23	prob 森林,碳汇,林业,面积,火灾,巴西,雨林,亚马逊,绿化,砍伐 frex 雨林,砍伐,森林,造林,木材,林业,热带雨林,碳汇,亚马孙,植树 lift 雨林,人工林,亿棵,双增长,砍伐,防护林,木材,林产品,造林,增汇 score 森林,碳汇,林业,火灾,亚马逊,雨林,砍伐,面积,树木,造林
precipitation	24	prob 台风,今年,我国,降水,常年,同期,地区,出现,气候,降水量 frex 台风,降水量,沙尘,登陆,梅雨,偏多,毫米,龙卷风,华西,偏少 lift 梅雨季,梅雨期,龙卷,七下,个数,偏西,八上,利奇马,大到暴雨,急转 score 台风,偏多,降水,汛期,降水量,常年,毫米,华西,偏少,沙尘
UNFCCC	25	prob 大会,会议,举行,框架公约,气候变化,缔约方,cop26,11,12,届 frex 框架公约,大会,cop26,缔约方,卡托维兹,届,格拉斯哥,马德里,会议,波恩 lift unfcc,卡托维兹,框架公约,第二十三届,埃斯皮,诺萨,帕特里,维茨,卡托,第十八次 score 大会,缔约方,框架公约,会议,cop26,格拉斯哥,卡托维兹,代表团,届,举行
Meteorological_Day	26	prob 世界,水,主题,气象日,今年,气候,2020,水资源,今天,未来 frex 气象日,世界,323,水,水日,主题,地球日,水资源,直面,珍惜 lift 水周,水是,之基,播讲,气象日,水为,水日,323,对水,之要 score 世界,气象日,主题,水,323,水日,水资源,地球日,今年,守护
urban	27	prob 城市,建筑,交通,设计,荷兰,规划,建设,空间,资讯,武汉 frex 建筑,城市,荷兰,交通,设计,c40,住宅,住房,资讯,城市气候 lift c40,海牙,规划设计,供稿,gfhs,热岛,建筑师,办公楼,建筑,荷兰 score 城市,建筑,荷兰,交通,规划,设计,c40,韧性,武汉,建设
summits	28	prob 气候大会,谈判,会议,多哈,德班,华沙,利马,气候,坎昆,京都议定书 frex 多哈,德班,华沙,坎昆,利马,谈判,卡塔尔,京都议定书,会场,王浩 lift 坎昆,cop20,lca,创绿,加时赛,多哈,寄望,德班,李丽娜,李雁 score 气候大会,谈判,多哈,德班,华沙,坎昆,利马,京都议定书,会议,代表团
contribution	29	prob 贡献,做出,国家,方案,作出,自主,提交,北京,体现,努力 frex 做出,贡献,倒计时,冬奥,自主,作出,奥运会,提交,两会,冬奥会 lift indc,冬奥,做出,奥运会,倒计时,两会,贡献,金牌,体育赛事,赛事 score 贡献,做出,自主,作出,方案,冬奥,冬奥会,两会,提交,倒计时
IPCC	30	prob 报告,发布,政府,指出,评估,委员会,最新,间,一份,ipcc frex 报告,ipcc,评估,专门,差距,发布,间,绿皮书,一份,委员会 lift ipcc,蓝皮书,读后,csrglobal,柳叶刀,报告,绿皮书,社会科学文献出版社,差距,中国社会科学院 score 报告,发布,ipcc,评估,委员会,最新,专门,政府,绿皮书,指出
GHG_emission	31	prob 排放,温室气体,二氧化碳,减少,中,排放量,碳,甲烷,大气,降低 frex 甲烷,二氧化碳,温室气体,排放,排放量,co2,释放,减少,封存,亿吨 lift ccus,排放物,甲烷,n2o,一氧化二氮,汇川,捕集,co2,二氧化碳,芬欧 score 排放,温室气体,二氧化碳,排放量,甲烷,碳,减少,大气,co2,亿吨
Eco_Civilization	32	prob 建设,工作,我国,推进,生态文明,生态,发展,加强,重点,推动 frex 成效,协同,十四五,生态文明,推进,十三,五,印发,建设,统筹 lift 481,五中全会,全面完成,国务院办公厅,建立健全,4045,体制改革,提前完成,控排,十二五 score 生态文明,建设,我国,印发,十四五,推进,协同,节能减排,规划,生态
UN	33	prob 秘书长,古特雷斯,表示,潘基文,呼吁,和平,人权,指出,领导人,各国 frex 古特雷斯,潘基文,秘书长,联大,和平,人权,纽约联合国总部,联合国大会,采取行动,一般性 lift 高级专员,联大,通谕,潘基文,古特雷斯,难民署,巴切,极端主义,首脑会议,发展权 score 潘基文,古特雷斯,秘书长,人权,和平,联大,领导人,联合国大会,平等,致辞
risk	34	prob 气候,变暖,全球变暖,地球,科学家,导致,全球,专家,警告,加速 frex 全球变暖,变暖,暖化,临界点,学家,变冷,霍金,温室效应,科学家,两极 lift 火山爆发,全球变暖,变暖,霍金,趣闻,临界点,暖化,652,冰河期,原色 score 变暖,全球变暖,地球,科学家,气候,导致,冻土,霍金,温度,反射
global_devlp	35	prob 发展,合作,习近平,世界,推动,国家,共同,经济,国际,人民 frex 习近平,中非,愿同,十国集团,一带一路,主义,共赢,金砖,共同体,重要讲话 lift 多边贸易,开放型,何立峰,合法席位,我谨,薛祥,互鉴,单边主义,便利化,扩大开放 score 习近平,合作,愿同,一带一路,多边,十国集团,中非,共同体,中方,金砖
regulation	36	prob 印度,垃圾,塑料,污染,处理,回收,单车,西方,分类,职责 frex 印度,单车,回收,垃圾,打通,莫迪,塑料,威尼斯,职责,分类 lift 单车,印度政府,慰问,排污口,阿三,可回收,印度人,印度,中印,打通 score 印度,垃圾,塑料,单车,莫迪,回收,打通,污染,职责,电动
UK	37	prob 英国,报道,称,表示,伦敦,宣布,网站,部,计划,外媒 frex 英国,英国政府,约翰逊,卫报,外媒,报道,greenisgreat,伦敦,王子,议会 lift 下议院,鲍里斯,chrishuhn,保守党,卡梅伦,威尔士,约翰逊,英国,英媒,英镑 score 英国,报道,称,伦敦,英国政府,大臣,卫报,约翰逊,部,外媒
scientist	38	prob 教授,科学,大学,研究所,院士,学院,奖,博士,获得,科学家 frex 教授,学院,经济学,奖,院士,奖项,清华,获奖,研究所,表彰 lift 罗默,诺贝尔奖,博士生,攻读,瑞典皇家科学院,荣膺,蒙民伟,该奖,诺贝尔经济学奖,豪斯 score 教授,奖,学院,院士,大学,科学,经济学,研究所,奖项,中国科学院

renewable	39	prob 太阳能,光伏,发电,新能源,再生能源,电力,风能,补贴,风电,储能 frex 光伏,储能,电网,电站,pvtech,太阳能,新能源,风电,发电,发电量 lift 电站,组件,pvtech,储能,兆瓦,发电能力,并网,投运,电网,solarzoom score 光伏,太阳能,发电,新能源,再生能源,储能,风能,风电,电站,电网
Europe	40	prob 欧盟,法国,欧洲,德国,马克,国家,龙,中欧,峰会,g7 frex 欧盟,法国,默克尔,欧元,德国,马克,法中,欧洲,g7,龙 lift 法兰西共和国,勒德,欧洲理事会,利亚斯,欧洲委员会,欧盟,法中,默克尔,冯德,法兰西 score 欧盟,法国,德国,欧洲,马克,默克尔,g7,中欧,欧元,龙
intnl_collaboration	41	prob 合作,举办,共同,领域,国际,探讨,联合,活动,研讨会,交流 frex 研讨会,竹藤,驻华,探讨,备忘录,主办,举办,南南合作,合作,先生 lift 总领事,安锋,sdc,中澳,中瑞,竹藤,inbar,nbs,志奋领,备忘录 score 合作,举办,南南合作,竹藤,研讨会,驻华,探讨,主题,主办,备忘录
/42	42	prob 气候,干燥,容易,疾病,养生,注意,人体,秋季,冬季,吃 frex 处暑,干燥,秋燥,养生,皮肤,中医,蚊子,人体,呼吸道,过敏 lift 机体,清热,五脏,干裂,打喷嚏,润肺,滋阴,燥,病症,莲藕 score 干燥,养生,处暑,人体,秋燥,秋季,疾病,感冒,饮食,皮肤
/43	43	prob 老师,孩子,今天,准备,一年,工作,里,会,带,中 frex 老师,凉,路上,大暑,上班,高考,早上,孩子,礼物,送 lift 地笑,大暑,高考,同此,得意,凉风,瓶,烫,秋高气爽,云彩 score 老师,孩子,大暑,凉,出游,高考,开学,回家,小暑,上班
equity	44	prob 粮食,农业,贫困,非洲,帮助,饥饿,儿童,安全,粮食安全,妇女 frex 妇女,贫困,粮农组织,儿童,粮食,粮食安全,生计,饥饿,性别,女性 lift 席尔瓦,亚太经社会,农村妇女,小农,粮农,智能型,世界粮食计划署,权能,粮农组织,女童 score 粮食,饥饿,贫困,粮农组织,妇女,农业,粮食安全,儿童,非洲,生计
mitigation&adaptation	45	prob 应对,积极,适应,减缓,措施,tnc,策略,达沃斯,对应,增强 frex 应对,积极,tnc,适应,减缓,措施,双赢,博客,策略,启示 lift 应对,tnc,说成,大有可为,积极,双赢,适应,数说,减缓,启示 score 应对,适应,积极,tnc,减缓,措施,达沃斯,策略,博客,政策措施
enviro_protection	46	prob 环保,聚焦,热点,演讲,行,熊猫,美丽中国,抗议,南京,联盟 frex 1831,普法,热点,毕业典礼,卧龙,958,心灵,绿之芽,熊猫,行 lift 23296,24888,560113669,兵仕,刁凡超,大明湖,控霾,梁景树仁,汪昭华,湿法 score 环保,演讲,毕业典礼,热点,1831,聚焦,卧龙,济南,美丽中国,普法
action	47	prob 气候变化,via,刻不容缓,知多少,看过,准备,菠菜,想不到,亿万,常用 frex 气候变化,via,知多少,刻不容缓,看过,菠菜,想不到,亿万,常用,没能 lift 气候变化,知多少,via,想不到,看过,刻不容缓,菠菜,亿万,没能,常用 score 气候变化,via,刻不容缓,知多少,看过,菠菜,想不到,亿万,常用,没能
temperature_rise	48	prob 全球,上升,气温,15,水平,升温,升高,摄氏度,控制,速度 frex 上升,升温,升高,海平面,摄氏度,水平,以内,工业化,2100,本世纪末 lift 万分之,升幅,400ppm,上升幅度,2c,华氏度,下半叶,升温,上升,海平面 score 气温,上升,全球,升温,升高,摄氏度,海平面,本世纪末,水平,海平面上升
carbon_trading	49	prob 碳,碳排放,市场,低,全国,减排,交易,政策,试点,权 frex 碳交易,交易,交易市场,权,碳排放,试点,碳,配额,交易所,碳税 lift 交易量,核证,碳税,交易市场,交易系统,吹风会,孙翠华,成交额,碳交易,成交量 score 碳,碳排放,市场,交易,碳交易,试点,交易市场,减排,权,全国
degradation	50	prob 土地,退化,恢复,臭氧层,荒漠化,保护,修复,防治,物质,消耗 frex 臭氧层,荒漠化,土地,退化,蒙特利尔,库布其,修复,臭氧,空洞,议定书 lift hfcs,基加利,库布其沙漠,治沙,荒漠化,蒙特利尔,三十周年,库布其,氟利昂,氟碳 score 土地,臭氧层,荒漠化,退化,议定书,蒙特利尔,臭氧,修复,防治,恢复
covid	51	prob 疫情,新冠,病毒,危机,流行,疫苗,冠状病毒,肺炎,复苏,更 frex 冠状病毒,新冠,疫情,流行,covid19,肺炎,病毒,小弟,疫苗,法制 lift 冠状病毒,covid19,一法,二制,依法治国,公检法,司法腐败,小馨馨,控告,无天 score 疫情,新冠,冠状病毒,疫苗,病毒,流行,肺炎,法制,危机,复苏
temperature_anomalies	52	prob 气温,寒潮,天气,南方,冷空气,高温,冷,广东,降温,北方 frex 寒潮,最低气温,冷空气,降温,冷,阴雨,南方,东北,南下,广东 lift 弱冷空气,雨夹雪,平爱萝莉,张方丽,强冷空气,最低气温,短袖,三伏,体感,省会 score 寒潮,冷空气,气温,天气,高温,南方,冷,最低气温,降温,阴雨
youth_engagement	53	prob 青年,活动,参与,项目,请,工作,欢迎,传播,参加,组织 frex cycan,招聘,青年,招募,报名,校园,青年人,使者,欢迎,感兴趣 lift 以上学历,詹育锋,youth4sdg,夏令营,招商局,招聘,邮箱,cycan,unv,实习生 score 青年,招聘,cycan,招募,报名,青年人,项目,参与,使者,活动
local_climate	54	prob 植物,生长,沙漠,气候,温暖,到来,中,提前,一片,里 frex 樱花,古树,开花,盛开,春风,落叶,敦煌,棉花,花,颜色 lift 樱花,古树,树叶,霜冻,湛蓝,发芽,盛开,绽放,敦煌,长出 score 植物,樱花,生长,沙漠,霜降,古树,落叶,棉花,春天,盛开
energy	55	prob 能源,再生能源,清洁能源,煤炭,石油,天然气,转型,清洁,化石燃料,消费 frex 煤炭,能源,清洁能源,石油,天然气,页岩,核能,氢能,油气,化石燃料 lift oilpric,核能发电,opec,lng,欧佩克,燃料电池,成品油,非常规,煤炭,压裂 score 能源,再生能源,煤炭,天然气,清洁能源,石油,页岩,转型,化石燃料,化石
natural_disaster	56	prob 极端,天气,发生,事件,气候,干旱,高温,灾害,洪水,频繁 frex 极端,飓风,频发,热浪,频率,洪水,遭遇,频繁,风暴,袭击 lift 极端,百年一遇,飓风,频率,暴风雪,袭击,频发,先知,桑迪,惨重 score 极端,天气,事件,干旱,高温,灾害,热浪,洪水,发生,频发
Eco-system	57	prob 湿地,生态,保护,重要,公园,草原,国家,雪豹,我国,生态系统 frex 湿地,雪豹,大熊猫,三江,候鸟,自然保护区,草原,源,水质,珍稀 lift 大熊猫,蓄洪,重点保护,金丝猴,保护意识,水禽,湿地,藏羚羊,防旱,雪豹 score 湿地,雪豹,生态,三江,大熊猫,保护,自然保护区,公园,草原,秦岭
lifestyle	58	prob 吃,食物,浪费,食品,生产,苹果,少,肉,饮食,减少 frex 浪费,肉类,牛肉,豆类,肉,好吃,苹果,饲料,水果,美食 lift 奶牛,肉类,舌尖,豆类,丰盛,植物性,牛肉,人造肉,奶制品,餐桌 score 吃,食物,浪费,水果,肉类,豆类,饮食,苹果,肉,食品

extinction	59	prob 澳大利亚,物种,灭绝,动物,珊瑚,数量,栖息地,威胁,消失,澳洲 frex 澳洲,澳大利亚,大堡礁,珊瑚,灭绝,白化,动物,蜜蜂,哺乳动物,大象 lift 传粉,澳大利亚广播公司,澳洲,亿澳元,白化,袋鼠,鳄鱼,大堡礁,裸尾鼠,交配 score 灭绝,物种,珊瑚,澳大利亚,动物,大堡礁,栖息地,鸟类,蜜蜂,澳洲
/60	60	prob 气候,节气,夏季,今日,北京,时节,季节,时,进入,寒冷 frex 节气,二十四节气,冬至,小雪,大雪,清明,时节,立冬,春分,夏至 lift 七十二候,分立,吃饺子,小满,春分,一候,三候,二十四节气,最短,冬至 score 节气,时节,冬至,二十四节气,小雪,惊蛰,寒露,立冬,秋分,春分
Sino-US	61	prob 中美,问题,合作,双方,国,美国,中方,两,联合声明,特使 frex 中美,美方,克里,联合声明,中美关系,两,王毅,中方,外交部,元首 lift 对华政策,所涉,涉疆,涉台,美方,克里,应约,中美,华春莹,汪文斌 score 中美,中方,双方,美方,联合声明,中美关系,克里,合作,特使,两国
polar_regions	62	prob 北极,融化,北极熊,南极,企鹅,冰,冰盖,地区,海冰,极地 frex 北极,北极熊,格陵兰岛,企鹅,冰盖,融化,格陵兰,冰层,海冰,帝企鹅 lift 冰原,格陵兰,冰融,北极熊,幼仔,格陵兰岛,活活,浮冰,海象,灰鲸 score 北极,北极熊,融化,南极,企鹅,海冰,冰盖,格陵兰岛,冰,冰层
/63	63	prob 加拿大,下降,占,增长,2017,10,约,预计,达到,超过 frex 加拿大,gdp,每经,亿元,香港,价格,人民币,同比,2005,上涨 lift 跌幅,亿加元,每经,现货,例,gdp,每经整,同比,人民币,白炽灯 score 加拿大,下降,价格,每经,亿元,增长,占,香港,gdp,人民币
documentary	64	prob 故事,文化,中,历史,纪录片,讲述,推荐,电影,艺术,传统 frex 讲述,故事,电影,艺术,艺术家,影片,纪录片,氣候,文化,书 lift 书单,新刊,好书,會,画作,荐,變化,變遷,氣候,讲述 score 故事,纪录片,文化,讲述,电影,作品,艺术,艺术家,推荐,氣候
agriculture	65	prob 农业,种植,作物,产量,气候,农民,条件,农作物,生产,种子 frex 作物,水稻,种子,转基因,小麦,玉米,咖啡,农作物,茶叶,大豆 lift 亩产,单产,新品种,茶农,茶文化,超级稻,转基因,土壤条件,水稻,稻米 score 作物,种植,水稻,农业,产量,咖啡,农民,种子,农作物,玉米
green_devlp	66	prob 绿色,低碳,金融,转型,低碳发展,节能,供应链,绿色发展,2021,推动 frex 债券,绿色,低碳,金融,吴昌华,see,供应链,投融资,tcg,发行 lift 吴昌华,cati,cteam,citi,scti,tcg,债券市场,滨州市,艾路明,thefutureacademi score 绿色,低碳,金融,债券,转型,低碳发展,供应链,节能,绿色发展,see
/67	67	prob 调查,科考,南极,考察,地震,野外,人员,冰山,地质,名 frex 守望,冰架,科考,考察,科学考察,地震,野外,科考队,队员,调查 lift 长城站,中山站,向导,科学考察,科考队,象岛,野外作业,雪龙,雪龙号,冰架 score 科考,南极,调查,冰山,野外,冰架,守望,考察,地震,科考队
photography	68	prob 冰川,拍摄,照片,图,记录,瑞士,摄影师,图片,摄影,一张 frex 拍摄,照片,摄影师,冰岛,摄影,镜头,画面,彩虹,影像,一张 lift 动画片,演讲台,王相军,拍摄,摄影师,冰岛,配音,照片,镜头,彩虹 score 冰川,拍摄,照片,摄影师,瑞士,王相军,摄影,冰岛,记录,消融
gov	69	prob 国家,中心,北京,主任,专家,战略,副,发改委,启动,应急 frex 主任,李俊,峰,寰宇,播出,中心,北京市,应急,发改委,委 lift natgeotv,何建坤,wechat,建设部,开班,李俊,收视,建坤,寰宇,徐华清 score 中心,发改委,主任,司,国家,战略,应急,北京,副,李俊
biodiversity	70	prob 生物,多样性,保护,公约,自然,绿会,丧失,生态系统,土壤,cop15 frex 绿会,多样性,生物,cop15,丧失,周晋峰,公约,第十五次,保护,土壤生物 lift maggi,国际部,土壤生物,媒是,媒绿会融,日绿会,绿会融,cop15,周晋峰,绿会 score 多样性,生物,保护,绿会,cop15,公约,丧失,生态系统,土壤,生态文明
sustainable_devlp	71	prob 发展,经济,国际,可持续发展,社会,持续,方面,组织,促进,中 frex 可持续发展,经济,社会,促进,国际,议程,发展,发挥,方面,持续 lift 工发,绿色增长,李勇,可持续发展,相关者,社会,经济,不可或缺,教科文组织,经济模式 score 可持续发展,经济,社会,发展,国际,促进,政策,议程,工发,增长
future	72	prob 会,可能,更,认为,这种,未来,变得,情况,出现,存在 frex 可能,会,变得,这种,或许,认为,担心,不会,更,意味着 lift 致死率,例子,大程度,海豚,或许,真菌,确切,耐药,很难,可能 score 可能,会,更,这种,认为,变得,不会,出现,真菌,存在
/73	73	prob 共,没,说,没有,想,真的,国家,不要,现在,不会 frex 没,、,真,哈哈哈,共,回来,哈哈哈哈,怕,反正,逼 lift mr,天朝,键盘,忽悠,希特勒,熊熊,白皮,求囚,得罪,资本家 score 共,没,吃,真的,想,哈哈哈,没有,觉得,说,真
public_awareness	74	prob 生活,方式,改变,每个,选择,使用,意识,活动,个人,行为 frex 生活,每个,方式,改变,熄灯,意识,日常生活,选择,息息相关,个人 lift 熄灯,电灯,americanenglish,生活,日常行为,星期六,圣诞树,关灯,每个,不必要 score 生活,改变,方式,每个,熄灯,选择,低碳生活,空调,小时,意识
policymaking	75	prob 标准,建议,考虑,进行,回应,立法,保护,规定,要求,法律 frex 立法,诉讼,马斯克,质疑,条例,标准,规定,回应,特斯拉,应当 lift 涉嫌,养老金,许可证,征求,起诉,诉讼,涉,国家所有,宪法,马斯克 score 立法,条例,诉讼,标准,马斯克,气候资源,回应,规定,法律,案件
Glasgow_Declaration	76	prob 气候,行动,峰会,采取,危机,政策,责任,21,强化,20 frex 行动,采取,峰会,联合宣言,强化,雄心,气候,回顾,责任,共同努力 lift 联合宣言,践,行动,作出努力,采取,附,紧迫性,焦点访谈,推动者,峰会 score 行动,气候,峰会,联合宣言,采取,危机,雄心,强化,政策,白皮书
ocean	77	prob 海洋,海水,生态系统,珊瑚礁,中,海洋生物,红树林,保护,陆地,提供 frex 海洋,红树林,海洋生物,酸化,珊瑚礁,海水,海底,渔业,海草,鲸鱼 lift 海草,渔业资源,鲨,浮游生物,蓝碳,酸化,红树林,海洋生物,鲸鱼,盐沼 score 海洋,珊瑚礁,海水,海洋生物,红树林,生态系统,酸化,捕捞,海底,氧气
crisis	78	prob 人口,地区,国家,死亡,面临,万人,超过,威胁,危机,亿 frex 人口,万人,淹没,人数,短缺,用水,缺水,亿人,印尼,死亡 lift 数十座,迁都,图瓦卢,基里巴斯,雅加达,人因,马尔代夫,淹没,索马里,恐将 score 人口,万人,死亡,亿人,水资源,2050,面临,亿,人数,流离失所

palaeoclimatology	79	prob 冰川,米,发现,湖泊,地区,青藏高原,河流,海拔,形成,火山 frex 火山,亿年,圈,喷发,岩石,万年前,冰芯,珠峰,冰冻,万年 lift 融水,冰崩,溃决,盐湖,钻取,高程,冰湖,冰芯,喷发,落基 score 冰川,湖泊,米,青藏高原,万年前,亿年,海拔,冰冻,火山,岩石
carbon_neutrality	80	prob 目标,实现,碳中和,2030,减排,年前,碳达峰,承诺,2020,达到 frex 目标,碳中和,实现,2030,2060,碳达峰,力争,峰值,净,设定 lift 2060,碳中和,目标,努力争取,年净,2045,实现目标,减碳,力争,实现 score 目标,实现,碳中和,2030,碳达峰,减排,承诺,零排放,2050,2060
business	81	prob 企业,投资,公司,苏格兰,行业,集团,政府,更,汽车,商业 frex 投资者,苏格兰,银行,投资,esg,达尔,公司,资产,企业,执行官 lift esg,ogci,必拓,letsdonetzero,scotlandisnow,达尔,abb,re100,上市公司,金融业 score 企业,投资,公司,苏格兰,投资者,esg,行业,集团,电动汽车,银行
meteorological_incidence	82	prob 气象,气候,天气,科普,服务,十大,减灾,气象局,2021,事件 frex 十大,气象,减灾,科普,防灾,气象局,春运,评选,服务,博物馆 lift 吉首,10301130,刘雅鸣,十大,蓝懒,气象万千,气象网,主播,科普活动,科普知识 score 气象,天气,科普,减灾,十大,气象局,防灾,服务,预报,灾害
tourism	83	prob 气候,旅游,位于,新疆,地方,独特,重庆,条件,景观,海拔 frex 游客,奇观,景区,酉阳,旅游,云海,雪山,探访,video,气候宜人 lift 雅丹,三面,云南省迪庆藏族自治州,最像,夏无,张广才岭,施业,缭绕,蜿蜒,酉阳 score 新疆,旅游,海拔,云海,景区,景观,游客,重庆,奇观,雪山
future_impact	84	prob 正在,中,进行,气候,未来,目前,出,众多,今日,刚刚 frex 正在,中,进行,目前,众多,未来,出,气候,刚刚,今日 lift 正在,进行,中,众多,刚刚,目前,出,今日,未来,气候 score 正在,中,进行,气候,未来,目前,众多,今日,刚刚,出



Appendix 3-B

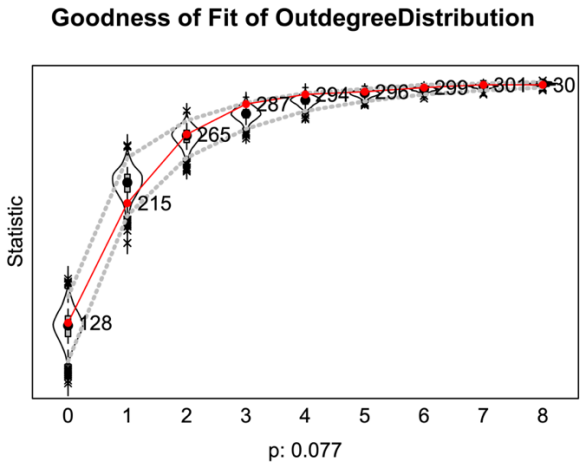
Table Appendix 3-B 2. Model terms

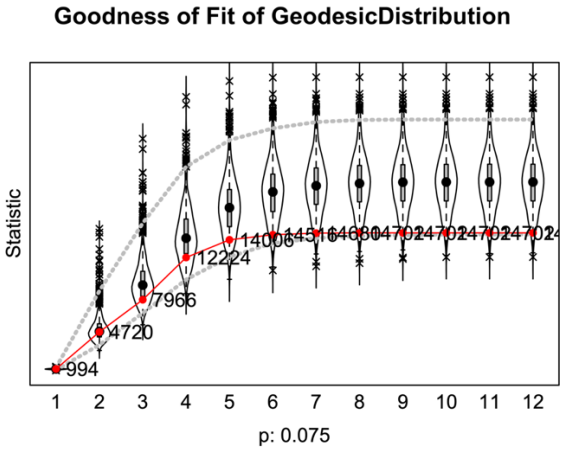
Terms	Effects	Description	Mathematic expression
		Endogenous network effects	
Reciprocity	*Reciprocity*	Tendency to form mutual ties	$\sum_j x_{ij}x_{ji}$
Transitive triplets	Transitive triplets (*transTrip*)	Tendency to interact with those to whom an indirect connection already exists (i.e., forming closed triplets)	$\sum_{j,h} x_{ij}x_{ih}x_{hj}$
Indegree popularity	Actor popularity (*inPopSqrt*)	Tendency of actors who have high in-degree to attract more incoming ties in the future	$\sum_j x_{ij}\sqrt{\sum_h x_{hj}}$
Indegree activity	In-degree activity (*inActSqrt*)	Tendency of actors who have high in-degree to send ties to others in the future	$x_{i+}\sqrt{x_{+i}}$
Outdegree activity	Actor activity (*outActSqrt*)	Tendency of actors who have high out-degree to send ties to others in the future	$x_{i+}\sqrt{x_{+i}}$
		Exogenous covariate effects	
Participation ego	Covariate-related activity (*egoX*)	Tendency of actors with high values on a certain covariate value to select others to form interaction ties (i.e., send more out-going ties in network)	$v_i^2 x_{i+}$
Participation alter; Follower size alter; Verification alter; Expert alter	Covariate-related alter activity (*altX*)	Tendency of actors with high values on a certain covariate value to be selected others to form interaction ties (i.e., receive more in-coming ties in network.)	$\sum_j x_{ij}v_j$
Outdegree	Network outdegree effect on participation behaviour (*outdeg*)	Tendency for more active actors (i.e., actors with a higher outdegree) to increase participation behaviour levels	$z_i \sum_j x_{ij}$
Indegree	Network indegree effect on participation behaviour (*indeg*)	Tendency for more popular actors (i.e., actors with a higher indegree) to increase participation behaviour levels	$z_i \sum_j x_{ij}$
Participation similarity	Similar covariate value (*simX*)	Tendency to form mutual ties with others who have similar covariate values	$\sum_j x_{ij}\left(sim_{ij}^v - \widehat{sim^v}\right)$
Average similarity	Average similarity in participation behaviour (*avSim*)	Tendency for actors adopting similar participation behaviour levels according to the average levels of their alters	$x_{i+}^{-1}\sum_j x_{ij}\left(sim_{ij}^z - \widehat{sim^z}\right)$

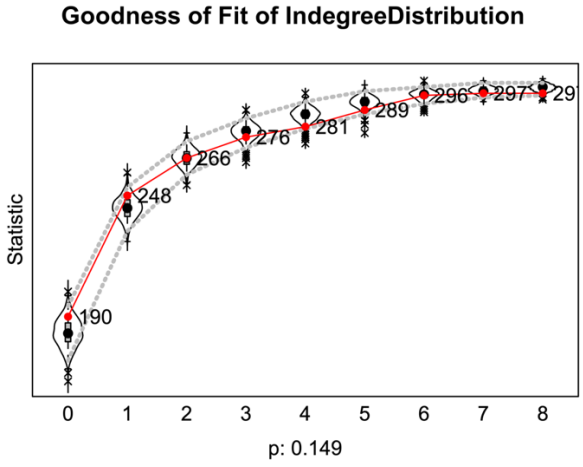
CC interest	Main covariate effect on participation behaviour (*effFrom*)	The main effect of certain covariate on actors' participation behaviour levels	$z_i v_i$

Appendix 3-C

GOF







Appendix 3-D

The screenshot of the chain-like dissemination and reshaping features of an example Weibo. Usernames and profile photos are anonymized to protect their privacy.


返回
公开
Reposting with comments
+关注
24-1-23 11:00 发布于 瑞士 来自 HUAWEI P50 Pro
上周参加达沃斯论坛，即将卸任的克里特使在发言中，特别提到了解特使对推动COP28气候大会达成共识做出的重要贡献。
Translate content
@贾
#联合国气候变化大会##cop28##做自然的朋友##绿色出行##碳达峰 碳中和#@公 @邹 @杨 @生 @奥 @正
贾 +关注
since 2007 Hou Liqiang reports.
United Nations Climate Change
COP28UAE
DUBAI 2023
离开舞台的气候外交超级明星
24-1-22 11:50
The original post
9 3 2
点赞是美意，赞赏是鼓励
赞赏作者
5 1 3 分享这条博文
说说分享心得
The reposting dissemination chain
同时评论 公开 转发
寻 ://@公 ://@正 :约翰·波德斯塔将接替约翰·克里，成为美国最高气候外交官 网页链接。 从我做起支持安全地发展核电超话 蔚蓝地图超话//@公 :上周参加达沃斯论坛，即将卸任的克里特使在发言中，特别提到了解特使对推动COP28气候大会达成共识做出的重要贡献。
24-2-2 22:04
公 ://@正 :约翰·波德斯塔将接替约翰·克里，成为美国最高气候外交官 网页链接。 从我做起支持安全地发展核电超话 蔚蓝地图超话//@公 :上周参加达沃斯论坛，即将卸任的克里特使在发言中，特别提到了解特使对推动COP28气候大会达成共识做出的重要贡献。 [微风
24-2-2 00:12
1
正 :约翰·波德斯塔将接替约翰·克里，成为美国最高气候外交官 网页链接。 从我做起支持安全地发展核电超话 蔚蓝地图超话//@公 :上周参加达沃斯论坛，即将卸任的克里特使在发言中，特别提到了解特使对推动COP28气候大会达成共识做出的重要贡献。
24-2-1 11:24
寻 ://@公 :上周参加达沃斯论坛，即将卸任的克里特使在发言中，特别提到了解特使对推动COP28气候大会达成共识做出的重要贡献。
24-1-23 21:49